Conservation through use: Lessons from the Mesoamerican dry forest

Adrian Barrance, Kathrin Schreckenberg and James Gordon

Conservation through use: Lessons from the Mesoamerican dry forest

Adrian Barrance, Kathrin Schreckenberg and James Gordon

This publication is an output from a research project funded by the United Kingdom Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID. R6913, Forestry Research Programme.

ISBN: 978-0-85003-894-1

Overseas Development Institute
111 Westminster Bridge Road
London SE1 7JD

Acknowledgements

This publication is an output of a research project (no. R6913) funded by the Forestry Research Programme of the United Kingdom's Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID. The project was jointly executed by the Department of Plant Sciences of the University of Oxford and the Overseas Development Institute, London.

We are indebted to the farmers of San Juan Arriba, Agua Zarca, San José de las Conchas and Los Coyotes in Honduras, and La Jabalina, El Sanjón, Petatengo and El Limón in Mexico for their contributions of time, information and hospitality, without which this study would not have been possible. We are grateful also to our numerous collaborators from institutions and projects of the Governments of Honduras and Mexico (federal, state and municipal), the agrarian authorities of Oaxaca, and NGOs in both countries (see appendix 5). In particular, thanks are due to the following for their help with identification of specimens: Antonio Molina (EAP), Jorge Araque (EAP), Ramón Zúniga (EAP), William Hawthorne (FHO), Mario Sousa (MEXU – Leguminosae), Hector Hernández (MEXU – *Zapoteca* & *Calliandra*), Cathrin Perret (SERBO – *Grajalesia*), Gabriel Flores (MEXU – *Senna*), Guillermo Ibarra (Instituto de Ecología, UNAM – *Ficus*), Jaime Jiménez (Fac. Ciencias, UNAM – *Jatropha*), Martha Martínez (Fac. Ciencias UNAM – Euphorbiaceae), M. Teresa Germán (MEXU – Meliaceae), Susana Valencia (Fac. Ciencias, UNAM – *Quercus*), Colin Pendry (RBGE – *Ruprechtia*).

In addition to the named authors of this publication, the following local researchers participated in the fieldwork: German Sandoval, Ramón Zúniga, Leticia Flores, Maritza Zuleta and Ángel Rodríguez in Honduras; and Thelma Ortiz Blas, Inti Escalona and Alberto Reyes García in México. Michael Richards and Jonathan Davies coordinated the economic fieldwork and analysis in Honduras and Mexico respectively.

The original idea and proposal for this research were developed jointly by Angus Brodie, Elizabeth Cromwell, Kate Schreckenberg and Michael Richards of the Overseas Development Institute, and Colin Hughes, William Hawthorne and David Boshier of the Oxford Forestry Institute. We are also grateful to John Palmer of the Forestry Research Programme, who provided invaluable technical guidance throughout the life of the project.

Author information

Adrian Barrance, formerly a Research Associate at the Overseas Development Institute, now specialises in designing biodiversity and sustainable land management projects for the Global Environment Facility, on behalf of the United Nations Development Programme, in Latin America and the Caribbean. He has a background in forestry and environmental impact assessment and a particular interest in integrating conservation and rural development.

Email: barrance@cablecolor.hn

James Gordon, formerly a Research Officer at Oxford University's Plant Sciences Department, now works for the Forest Conservation Programme of the International Union for Conservation of Nature (IUCN) where he works on landscape aproaches to forest conservation. He has a background in forestry, botany and economics and a particular interest in the ecology and use of tropical forests.

Email: james.gordon@iucn.org

Kathrin Schreckenberg is a Research Associate of the Overseas Development Institute. With a background in botany and social forestry, her research focus is on all aspects of forest governance and development of participatory research methodologies. She has a particular interest in the role of forests in poverty reduction, collaborative forest management, natural product value chains, the access of small-scale producers to markets and forests in climate change policy.

Email: k.schreckenberg.ra@odi.org.uk

Executive summary

This book examines the concept of 'conservation through use' (CTU), using the conservation of tree species diversity in Mesoamerican dry forest in Honduras and Mexico as a case study. It discusses the need to develop conservation strategies based both on a botanical determination of those species most in need of conservation and an understanding of the role these trees play in local livelihoods.

Mesoamerican tropical dry forest (MTDF) is an important biome for rare and economically important tree and shrub diversity. It has, however, suffered severe deforestation, largely through clearance for smallholder agriculture and for ranching. The need to conserve this diversity without compromising the already fragile livelihoods of the inhabitants of the region led the UK Government's Department for International Development (DFID) to fund a research project 'Conservation through Use of Tree Species Diversity in Fragmented Mesoamerican Dry Forest' (CUBOS) for four years from 1998. The results of that project, based on multidisciplinary research in two case study areas are collated and discussed in this book.

CUBOS aimed, through a combination of botanical and socioeconomic research, to identify effective and sustainable strategies for the conservation of tree species diversity in the MTDF, compatible with local cultural and tenure conditions and the development needs of the local population. Its secondary aim was to contribute to an improved understanding of the conditions under which conservation through use may in general be an effective strategy to conserve endangered species and/or habitats.

Key questions addressed by the research included the following:

- What benefits do farmers obtain from MTDF trees and forests, how do these benefits influence their management decisions and how can they be increased?
- On which MTDF tree species, land uses and sites should conservation efforts be concentrated?
- Under what circumstances is conservation through use an effective strategy to conserve MTDF tree species and ecosystems?

Within the broad field of conservation and development, the study restricted itself to a consideration of tree and shrub species in productive landscapes and focused on determining conservation priorities from a global perspective. It used a rapid botanical survey to define which species and sites in the case study areas are of highest priority for conservation. Unlike much other work, which bases conservation decisions on biodiversity (a measure of numbers of species, regardless of their conservation importance), this study used the concept of bioquality (a measure of the proportion of rare species in the vegetation, weighted by their global rarity).

The research was carried out in two contrasting case study areas chosen to represent conditions in much of the rest of the tropical dry forest zone of Mesoamerica, with the aim that the information generated and strategies identified in the course of the research should be of relevance throughout the region, and wherever possible beyond.

The first case study area was southern Honduras, which, in common with much of the rest of the Pacific slopes of Central America, is dominated by a highly disturbed dry forest agroecosystem. Here many farmers were found to actively protect trees they valued, particularly for timber. The extent of this conservation through use depended upon a number of factors: the level of demand for the tree's products and services and their availability from off-farm or purchased sources; the degree to which the species concerned tolerates conditions in the agro-ecosystem, and regenerates well; the security which farmers feel over their future rights to reap the benefits from the trees; and the effectiveness and flexibility of regulation.

The second study site of coastal Oaxaca contrasted sharply with southern Honduras, having large areas of apparently intact MTDF and with strong community-based controls on natural resource management existing in some parts of the area. Here conservation through use was found to operate largely at the communal, rather than individual, level, and to affect both forests as a whole and individual tree species. As in southern Honduras, the principal factors which determine the implementation of conservation through use in coastal Oaxaca include the existence of demand and markets for the products of trees and forests; the level of scarcity of the products and services of trees and forests; and the effectiveness of regulation, in this case at the community level.

The botanical survey produced a checklist of tree and shrub species for both sites, assessing their global rarity and indicating the land use types in which they are most likely to be found. The highest levels of bioquality were found in the most intact and largest forest areas of the Oaxaca case study area. Most of the high bioquality forests would be considered small and fragmented by global standards. However many of the agricultural areas which surround them are also of high bioquality, and may be important for maintaining biological connectivity between the forests. Communal organisation, management and control have contributed to conservation in Oaxaca. They have led to activities being zoned and regulated by local communities and benefits being shared between forest users. These systems are, however, under threat from trends towards private land ownership.

Although supporting surprisingly high levels of tree diversity, given the degree of disturbance that it has undergone, the southern Honduran agroecosystem is of relatively low bioquality in terms of tree and shrub species. No patches of high bioquality mature forest remain and most of the species there are widespread, adapted to disturbance and not of global conservation importance.

In both study areas, there is little overlap between those species which farmers value and protect, and those which are most threatened. None of the 108 species mentioned as used by the farmers interviewed in southern Honduras, and only 4 of the 281 mentioned in coastal Oaxaca, are globally rare. Conservation through use at the species level therefore appears to have limited value for biodiversity conservation. CTU at ecosystem level has more potential because it can lead not only to the conservation of the forest ecosystem as a whole (as we found in Oaxaca) but also, incidentally, of many priority species within the forest.

In order to determine the potential of CTU in any given case and to develop strategies for its promotion, it is important to understand whether the person or people benefiting from the conservation are directly or indirectly responsible for implementing conservation activities, whether CTU is ensured through regulation and/or incentives, and whether species and/or ecosystems are the object of conservation.

Key recommendations from this research include:

- Communities in coastal Oaxaca (and other areas with similar conditions of tenure, organisation and bioquality) should be supported in carrying out CTU in communal forests, where this approach has proved effective in conserving tree and shrub species of high global conservation priority.
- Farmers on the Pacific slopes of Honduras (and other areas with similar production systems and trees with similar characteristics) should be supported in carrying out CTU of naturally-regenerated trees in fields, thus maintaining supplies of tree products of importance for their livelihoods. Given the low numbers of globally rare tree and shrub species in these agroecosystems, this form of CTU should be seen primarily as a rural development issue, rather than one of biodiversity conservation.
- Given that CTU does not necessarily conserve ecosystems in an intact state and may be affected by changes in social and economic conditions, complementary support should continue to be provided to the establishment and management of protected areas, in those parts of the MTDF zone with globally important biodiversity, and where these are socially and politically feasible and likely to be financially sustainable.
- ‘Backstopping’ strategies should be developed for globally-important species which cannot be conserved effectively through either CTU or in protected areas (due for example to their limited valuation by local people, unfavourable conditions of tenure and community organization, their inability to prosper in disturbed environments or excessive levels of pressure). These strategies may include, for example, *ex situ* conservation.
- Decisions on conservation priorities and strategies elsewhere in the MTDF should be taken on a case-by-case basis, and in an informed and objective manner, based on systematic inventories of the numbers of high conservation species which they contain and investigations into productive, organisational, economic and tenure conditions.

Contents

Boxes

Tables

Figures

Photo credits

A. Barrance, pages: 37, 39, 46, 55 and 85
J. Gordon, pages: 1, 9, 16, 23, 31, 44, 49, 50, 65, 67, 73, 74, 79, 83, and 84

Glossary and abbreviations

AFE-COHDEFOR	Honduran State Forestry Authority – Honduran Corporation for Forest Development (replaced by the ICF in 2008)
Campesino	Peasant
CODE	Oaxacan Committee for Ecological Defence
COHAAT	Honduran-German Food for Work Cooperation project
COHASA	Honduran-German Food Security project
CONABIO	National Commission for Biodiversity (Mexico)
CONAFOR	National Forestry Commission (Mexico)
CONANP	National Commission for Protected Areas (Mexico)
CTU	Conservation through use
CUBOS	'Conservation through use of tree species diversity in fragmented Mesoamerican Dry Forest' project
DFID	Department for International Development (UK)
EAP	Pan American Agricultural School in Honduras
Ejidatario	Formal member of an ejido
Ejido	Area of communally managed land provided for in the agrarian reform which followed the Mexican Revolution
FONATUR	National Trust Fund for Tourism Development (Mexico)
GHI	Genetic Heat Index
GTZ	German Agency for Technical Development Cooperation
ICDP	Integrated Conservation and Development Project
ICF	Institute for Forestry Conservation and Development (Honduras) (replaced AFE-COHDEFOR in 2008)
INE	National Ecology Institute (Mexico)
IUCN	International Union for Conservation of Nature
Maicillo	Drought-resistant sorghum variety (Sorghum bicolor)
MBC	Mesoamerican Biological Corridor
Mestizo	Mixed race
MEXU	National Herbarium of Mexico
MTDF	Mesoamerican tropical dry forest
NGO	Non-governmental organisation
NTFP	Non-timber forest product
PRA	Participatory Rural Appraisal
PROCAMPO	Programme of Direct Support to the Countryside (Mexico)
PROCEDE	Programme for Certification of Ejidal Rights and Land Titling
PRONADERS	National Programme for Sustainable Rural Development (Honduras)
SAG	Secretariat of Agriculture and Livestock (Honduras)
SAGARPA	Secretariat of Agriculture, Livestock, Rural Development and Fisheries (Mexico)
SEMARNAT	Secretariat of Environment and Natural Resources, (Mexico)
SERNA	Secretariat of Natural Resources and Environment (Honduras)
SINAPH	National System of Protected Areas (Honduras)
Solar	Homegarden
WWF	Worldwide Fund for Nature

1. Conservation through use: The debate

In this chapter we outline the concept of conservation through use, highlight the key questions to be addressed in this book and provide a brief introduction to the Mesoamerican tropical dry forest zone.

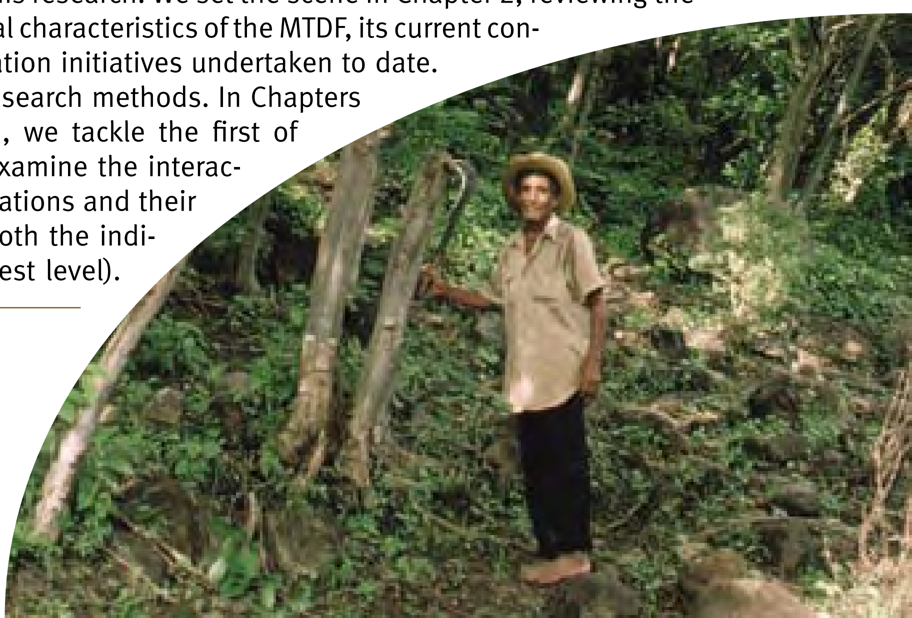
Aims and objectives

In this book we set out to explore the concept of 'conservation through use' (CTU), using the conservation of tree species diversity in Mesoamerican tropical dry forest (MTDF) in Honduras and Mexico as a case study. The background to this work is the need to develop conservation strategies based both on a botanical determination of those species most in need of conservation and an understanding of the role these trees play in local livelihoods. To contribute to this endeavour, we ask the following questions:

- What benefits do farmers obtain from MTDF trees and forests, how do these benefits influence their management decisions and how can they be increased?
- On which MTDF tree species and sites should conservation efforts be concentrated?
- Under what circumstances is CTU an effective strategy to conserve MTDF tree species and ecosystems?

To answer these questions, we draw on the results of a four year research project 'Conservation through Use of Tree Species Diversity in Fragmented Mesoamerican Dry Forest' (CUBOS), funded by the UK Government's Department for International Development (DFID). This project was jointly implemented by the Oxford University Department of Plant Sciences and the Overseas Development Institute, with support from and in consultation with, a wide range of government and non-government institutions in Honduras and Mexico.[1]

In this introductory chapter, we briefly review the debate on conservation and development and explain why the MTDF is an appropriate case study for examining conservation approaches that also seek to support local livelihoods. We define CTU and highlight some key assumptions underlying this research. We set the scene in Chapter 2, reviewing the socioeconomic and biophysical characteristics of the MTDF, its current conservation status and conservation initiatives undertaken to date. In Chapter 3 we outline our research methods. In Chapters 4 (Honduras) and 5 (Mexico), we tackle the first of our research questions and examine the interactions between the local populations and their tree and shrub diversity (at both the individual tree and the whole forest level).



Regenerating natural forest is important for farmers in southern Honduras as a source of firewood and timber

1. Key institutions active in the MTDF zone are listed in Appendix 5

Our second question relating to conservation priorities is the subject of Chapter 6 in which we present the results of our botanical research, regarding the relative conservation importance of the two case study areas, and of different sites and land uses within each. Our third research question is covered in Chapter 7, in which we take a more detailed look at how CTU works in the MTDF. This is followed by some recommendations in Chapter 8 on how CTU can be implemented more effectively.

The debate on conservation and development

In recent decades, conservationists have come to realise the shortcomings of approaches to conservation based on exclusion and protection (Utting, 1993). In most cases protected areas were established with scant attention to land tenure problems, the development needs of local people or how to finance the high costs of patrolling and protection (Wells and Brandon, 1992). They have also led to severe social impacts through the displacement of native peoples or the curtailment of the productive activities on which those people depend (Brockington and Schmidt-Soltau, 2004). By locking up resources, they commonly represent a significant opportunity cost to developing countries.

In the 1980s, sustainable development emerged as an alternative to earlier protectionist strategies that viewed conservation and development as opposing interests and therefore sought to establish large national parks and other reserves where 'natural' ecosystems could be protected from human influences (Schelhas et al., 2001). An early approach which recognised the compatibility between sustainable use and the conservation of biological diversity was promoted by the Man and Biosphere Programme of the United Nations Environmental, Social and Cultural Organisation (UNESCO). Its flagship biosphere reserves combined protected core zones with surrounding buffer zones in which a wide range of activities was permitted. The term Integrated Conservation and Development Project (ICDP) emerged as a collective label for a new generation of projects that started to go outside park and reserve boundaries and pay particular attention to the welfare of local people (Wells and Brandon, 1992). Some initiatives went further than simply tolerating use, to actively encouraging it on the assumption that if local communities benefited from the resource, they would be motivated to participate in and contribute to efforts to protect it. This constitutes 'conservation through use' (CTU).

In the environmental and development dialogue of the late 1980s, and especially in the 1990s following the United Nations Conference on Conservation and Development in Rio de Janeiro, there was an upsurge of interest in identifying and promoting situations in which CTU might work, where natural resources could be used in ways which would encourage local communities to conserve them and, at the same, would contribute to the social and economic wellbeing of the local people. These included both extractive uses such as non-timber forest products (NTFPs) and non-extractive uses such as the provision of, and payment for, environmental services. Much early work on CTU focused mainly on agricultural crop varieties (Altieri and Merrick, 1987; Cooper et al., 1992; del Amo, 1992a and 1992b; Pimental et al., 1992).

The concept was then widely applied to NTFPs where it was more commonly known as the 'use it or lose it' philosophy (Freese, 1997). Conservation and development organisations alike, particularly those working in the tropical rain forest, promoted the idea that NTFP production and trade had the potential to supply local people with sufficient incomes to provide them with incentives to maintain the forests (Nepstad and Schwartzman, 1992; Ruiz Pérez and Arnold, 1996; Wollenberg and Ingles, 1998). Governments also took an interest with Brazil making a high profile commitment to extractive reserves, where it was hoped that livelihoods based on a combination of rubber tapping and brazil nut harvesting would ensure forest conservation. However, two decades and many NTFP initiatives later, Belcher and Schreckenberg (2007) caution against the optimism still prevailing in some quarters that NTFP commercialisation can be an easy answer to the problem of achieving species and ecosystem conservation at the same time as improving local livelihoods.

CTU also lay at the heart of widespread implementation of community forestry. While early support was motivated by donors' and governments' interests in improving the conservation status of forests, this soon gave way to an interest in community forestry as a route to reducing poverty. This shift in emphasis took place within the context of a global focus on poverty reduction (as illustrated by the Millennium Development Goals and the promotion of national Poverty Reduction Strategies) and the assumption that the very location of many of the world's poorest people in and around forests suggested an important role for forests in poverty alleviation (Hobley, 2006). Community forestry, in which local communities are given varying levels of control over adjoining forests, appeared to be an obvious way to achieve poverty reduction. There is some concern, however, that we have very little idea of the extent to which PFM models developed in different situations have had positive benefits in terms of either biodiversity conservation and/or poverty alleviation (Schreckenberg et al., 2002).

In several areas, therefore, it has become clear that the CTU approach has limitations, and that a number of the basic assumptions on which it depends remain inadequately tested. Some researchers point out that the concept has tended to be used too simplistically, without adequate definition of what aspects of biodiversity were to be conserved (e.g. Redford and Richter, 1999). Others have highlighted the different and often difficult conditions that have to be met, for example in terms of secure tenure, resource inventory and management, producer organisation and market access, for sustainable examples of CTU such as NTFP extraction or community forestry to be feasible.

In parallel with a search for effective approaches to achieve simultaneous conservation and development, there has been growing recognition that it is not possible to create sufficient protected areas to conserve all species (Hutton and Leader-Williams, 2003). It seems that what happens outside protected areas will be as crucial for effective conservation of biodiversity as protection of *in situ* reserves. Most conservation will therefore have to be achieved though co-operation in human social space (Ghimire and Pimbert, 1997). There is thus a strong case for paying greater attention to the role and potential of human-managed ecosystems in fulfilling the goals of biodiversity conservation.

The Mesoamerican tropical dry forest as a case study

There are few ecosystems worldwide where there is more need to reconcile the goals of conservation and development than the Mesoamerican tropical dry forest (MTDF). This ecosystem is of great global importance for conservation: it contains many species with severely restricted natural ranges (Janzen, 1986, 1988; Murphy and Lugo, 1995; Maass, 1995) and Mexican dry forests are classified by the Worldwide Fund for Nature (WWF) as 'critical/endangered' and as one of the Global 200 priority ecoregions worldwide (Olson et al., 2001). Conservation of the MTDF can be considered an international priority both as a unique ecosystem and as a store of genetic variability of proven current value (Gordon et al., 2004). Many tree species originating in the MTDF have been shown to have great potential to contribute to rural development in different parts of the world (see Chapter 2).

The trees and forests of the MTDF are highly important for the livelihoods of local people, as a source of products such as timber, firewood and fruit, and of services such as water supply and soil conservation. These uses have in many cases been linked to the deforestation and degradation of the MTDF ecosystem over much of its natural range, reducing its conservation value at global level and also increasing the vulnerability of local people's livelihood support systems. However, placing tighter restrictions on local people's activities, in order to conserve trees and forests, would risk further compromising their already fragile livelihoods in the short term. There is therefore a clear need for effective and sustainable strategies for resource management, which contribute actively to conservation and, at the same time, are compatible with the immediate needs of the local population.

Tropical dry forests have received very little conservation effort relative to humid tropical forests, in part because of the high economic value of the goods and services that can be extracted from tropical dry forests (Sánchez-Azofeifa et al., 2005). The current very limited and scattered network of dry forest reserves in Mexico and Central America cannot adequately conserve the MTDF. Compared to other regions, the area of tropical dry forest protected in Central America is still disproportionately low (Miles et al., 2006). Furthermore, there is now only limited scope for the establishment of new protected reserves due to the extent of forest loss and fragmentation. The forest-agriculture frontier has long since gone in Central America and been replaced by an intimate and highly localised mosaic of small and vulnerable forest remnants amidst a diffuse matrix of trees outside the forest in even smaller patches of remnant woodland, in traditional agroforestry systems on farms, in fence-rows, homegardens and around settlements (Janzen, 1988).

It seems that the only option for achieving conservation goals over much of the region, therefore, is to incorporate conservation criteria into forest and farm management practices. This makes the MTDF especially interesting as a case study for CTU, because much of its biodiversity exists outside of protected areas, providing an opportunity to study the potential of CTU in productive landscapes. Researchers have also suggested that CTU is already a reality in the MTDF, and that a number of species owe their current conservation status to the fact that local people value their products and therefore nurture and protect them (Hughes, 1998). This may provide an opportunity to learn from and build upon traditional practices.

A definition of CTU

Conservation through use is a term that covers a wide range of situations. Here we define it as *the conservation of any resource, motivated by perceptions of its utility*.

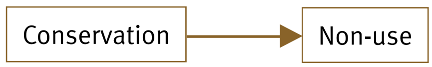
The 'utility' referred to in this definition may result from cash or subsistence benefits which arise from the resource in question (for example through the sale or use of its products) or from non-cash benefits such as the provision of environmental services (for example water or aesthetic enjoyment).

This definition of CTU implies a self-stabilising 'win-win' situation in which the benefits from using a resource lead to its conservation, and this conservation in turn permits the resource to continue providing benefits. It is important to distinguish this situation from other less complementary relationships between conservation and use (Box 1.1).

Box 1.1 Gradient of relationships between conservation and use

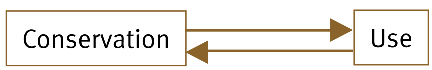
1. **Incompatibility**: over-extraction ('Resource mining' in which use is incompatible with conservation, or does not motivate conservation and leads to the resource being actively degraded)

2. **Incompatibility**: strict conservation ('The no-touch approach' in which use is prohibited in order to achieve conservation, as applied in some protected areas)



3. **Compatibility**: neutral interactions ('Conservation with use' in which use presents no problems for conservation, e.g. in the case of enjoyment of the aesthetic value of a landscape or the downstream consumption of water from a protected watershed forest)

4. **Complementarity** ('Conservation through use' in which people's use of a resource leads to their conserving it, which in turn ensures that the resource continues to exist for their use)



As we use it in this book, CTU has two defining features:

- *Its principal aim is conservation.* This distinguishes CTU from other approaches to on-farm tree management, which are primarily concerned with the contribution of trees to farmers' livelihoods and do not necessarily lead to significant global conservation benefits.

- *It involves positive decisions to conserve resources.* For example, the management of trees on farm, aimed at maintaining a valued native tree resource, qualifies as CTU as it is a positive strategy motivated by the use value of the tree in question; whereas the passive acceptance of non-valued trees on farm is not. CTU is thus associated with the purposeful introduction of agroecosystem components by farmers, or 'planned biodiversity', in contrast to 'unplanned biodiversity' components that colonise without human help (Vandermeer and Perfecto, 1997; Altieri, 1999).

CTU may occur in either intact or disturbed ecosystems, and may be applied either to the ecosystem as a whole (e.g. a forest) or to components of the ecosystem (e.g. individual tree species).

Underlying assumptions

The research approach used to examine the CTU concept was based on a number of underlying assumptions.

There are many objectives for conservation

Different aspects of the MTDF are important to different stakeholders (see Table 1.1), and may require different conservation strategies. Lack of clarity regarding the objectives of conservation has been one of the reasons for its limited effectiveness to date. In this book we focus on the first two stakeholder groups in Table 1.1, comparing the priorities of conservationists and local people in terms of the management and conservation of different sites and species. Different stakeholders have different degrees of power as conservation actors/decision-makers. The key drivers of forest and species loss in some areas may be large landowners and corporations. However, we focus our attention on the conservation actions of small-scale farmers in the two study areas in recognition of the fact that their strong livelihood dependency on natural resource management and consequent vulnerability to poorly conceived conservation strategies makes this a particularly challenging environment in which to develop appropriate conservation solutions.

Conservation priorities can be set at a global level

A critical decision taken in the study was to compare conservation priorities among tree and shrub species (and consequently among the sites where they occur) from a *global* perspective. This is based on the argument that local extinctions (while potentially of great concern for species with important local ecological or livelihood roles) can in theory be reversed through reintroduction or re-establishment, whereas a species that becomes extinct at global level is gone forever. The global value of biodiversity is now widely recognised. This is reflected in the increasing internationalisation of policy formulation, decision making and resource allocation in conservation and is exemplified by policies, mechanisms and institutions such as the United Nations Convention on Biological Diversity, the Global Environment Facility and WWF. This is not to say that national governments may not also have an interest in setting national-level conservation priorities if the global threat status is not considered to adequately reflect the country's biodiversity conservation needs.

Prioritising sites for conservation requires an assessment of bioquality

The first step in the systematic planning of conservation is to measure and map biodiversity (Margules and Pressey, 2000). However, biodiversity assessments only consider the total numbers of species present, irrespective of their conservation status. In order to prioritise sites for conservation, we assume that it is necessary to go a step further and assess 'bioquality', which takes into account the conservation priorities of the different species found in a given site. The methods used in arriving at an index of bioquality per site are detailed in Chapter 3 and Appendix 1.

Table 1.1 Stakeholder interests in the MTDF

Conservation objective	Stakeholder group	Rationale
Total numbers of species, populations and individuals of flora and fauna	Conservationists and the global public	Wish not to lose species from the planet, because of existence value and/or option value (potential utility)
Adequate quantities of certain valuable species, in appropriate condition (e.g. stem size and tree form)	Local populations	Need for products for subsistence or income generation
Adequate population levels and population diversity of globally useful tree species	Development agencies, small farmers and forest plantation managers	Potential for use in agroforestry systems or plantations elsewhere in the world
Total biomass	Global public	Carbon sink, reducing the risk of impacts on the global climate
Total vegetation cover and structure	People living downstream	Capacity of the forest to regulate stream flows

A focus on trees is valid from both a conservation and a livelihoods perspective

This book focuses specifically on trees in the MTDF. This is because they are of fundamental importance to local people's livelihoods, as well as having a very high global 'use value'. As targets for conservation they are also more easily managed by farmers than wildlife, for example. Furthermore, many of them appear to be under threat from pressures such as felling for timber and conversion of forests to other land uses. They are therefore prime candidates for CTU. However, many of the concepts discussed are applicable to other forms of flora and fauna, and to other forest types or regions where conservation priorities and local people's development goals need to be reconciled.

Socioeconomic, cultural and biophysical conditions vary widely throughout the MTDF region

In extrapolating the results presented here beyond the two areas on which this study focuses (described in Chapter 2), the reader should take into account the specific socioeconomic, cultural and biophysical characteristics of these study areas, and the fact that these conditions vary widely across other parts of the MTDF zone and across other ecosystems and regions.

2. The Mesoamerican tropical dry forest in context

The Mesoamerican tropical dry forest (MTDF) has been subjected to alteration, fragmentation and deforestation as a result of human activity. Many of the people living in the MTDF zone suffer severely from poverty, which is exacerbated by the erosion of the natural resource base on which they depend. Traditional approaches to conservation, based on state regulation and the establishment of protected areas, have had limited success because of pressures from the local population to use land and tree resources to support their livelihoods, and poorly developed conditions of governance. There is also a risk that conservation initiatives based on exclusion will impose significant social and economic costs on local people. Alternative conservation strategies are therefore called for in the MTDF.

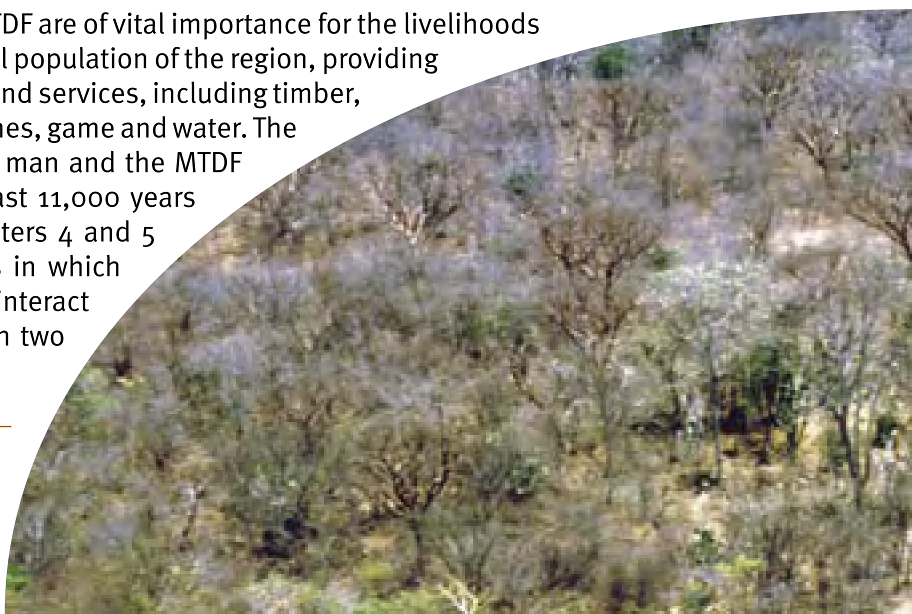
Where and what is Mesoamerican tropical dry forest?

Dry forest once stretched from the Azuero peninsula in Panama to Baja California Sur in northern Mexico. Between these two extremes, the natural range of Mesoamerican tropical dry forest (MTDF) covers most of the Pacific coast of Mexico and Central America, many interior valleys and also parts of the Yucatán peninsula in Mexico (Fig. 2.1). It is usually found below 1,000 metres above sea level, on coastal plains and foothills, although in interior valleys it may reach higher altitudes. Virtually all of the forests described here are found within the (sub)tropical dry forest (*bosque seco (sub)tropical*) life zone (Holdridge et al., 1971).

Specific characteristics of MTDF are that it has a closed canopy in its undisturbed state and is deciduous (away from permanent watercourses) with at least 50% of canopy species losing their leaves for at least 3 months of the year because of seasonal drought. However, rainfall is typically highly variable between years, with ecological consequences that are not yet fully understood. Included in this definition are both low deciduous forest (*selva baja caducifolia*) and medium semideciduous forest (*selva mediana subcaducifolia*).

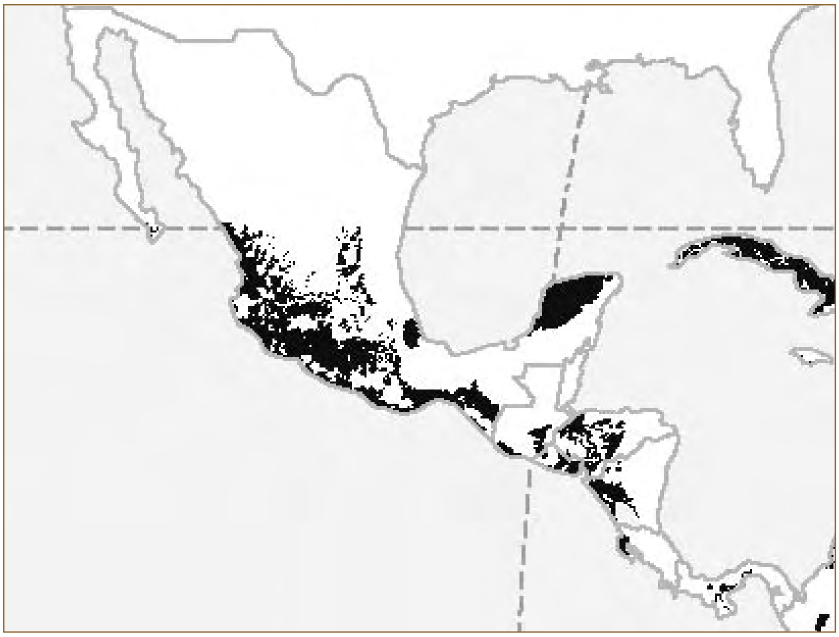
Why is Mesoamerican tropical dry forest (MTDF) important?

The trees and forests of the MTDF are of vital importance for the livelihoods of the predominantly poor rural population of the region, providing them with essential products and services, including timber, firewood, fodder, fruit, medicines, game and water. The intimate association between man and the MTDF is thought to date back at least 11,000 years (Bullock et al., 1995). In chapters 4 and 5 we look in detail at the ways in which local people depend on and interact with MTDF trees and forests in two case study areas.



Dry forest, here in southern Honduras, is characterised by seasonal loss of leaves

Figure 2.1 The distribution of Mesoamerican tropical dry forest in the year 2000



Source: Miles et al., 2006

The MTDF is also of great global importance. From a biological viewpoint, it is of interest because of its unique fauna and flora that includes elements from both South and North America. It also contains a large number of endemic species: for example both the North Central American Pacific Slope and the South Central American Pacific Slope are classified by BirdLife International (2003) as Endemic Bird Areas, of 'high' and 'urgent' conservation priority respectively. WWF classifies Mexican dry forest as one of the Global 200 most biologically outstanding habitats in the world and considers it to be "the richest tropical dry forest in the world with high levels of regional and local endemism" (WWF, 2004). In Costa Rica, an 11,000 ha area of dry forest in Santa Rosa National Park was estimated to contain 13,000 species of insects, 175 breeding species of birds, 115 species of non-marine mammals and 75 species of reptiles and amphibians (Janzen, 1988).

Many important crops such as maize, beans and squashes were domesticated from the MTDF (Toledo et al., 1989; Maass, 1995). It is also home to a large number of globally useful and versatile tree and shrub species, with characteristics such as durable timber, rapid growth, palatable fruits and the ability to coppice, fix nitrogen and withstand prolonged drought. These characteristics have led to many of them being planted elsewhere in the tropics, where a number (e.g. *Leucaena leucocephala* and *Gliricidia sepium*: Hughes, 1998; Stewart et al., 1996) now form the basis of smallholder livelihoods and commercial forestry enterprises. In

MTDF at the turn of the Millennium

Throughout most of its range, MTDF has been severely altered by centuries of human activity, dating from pre-conquest times and increasing in intensity to the present day. In 1986, it was estimated that less than 2% of the 550,000 km^2 of dry forest that existed on the Pacific coast of Mesoamerica when the Spanish arrived, was by then "sufficiently intact to attract the attention of the traditional conservationist" (Janzen, 1986). When intact dry forest is replaced by fencerows, ditches, pastures and woodlots, the species richness of the breeding fauna and flora is reduced by 90 to 95% (Janzen, 1988). In Mexico, only 27% of the original cover of seasonally dry tropical forest remains (Trejo and Dirzo, 2000). The gloomy picture is supported by Miles et al. (2006), who rank MTDF as among the most threatened dry forest regions on earth.

A number of different landscapes can be distinguished today in the area over which MTDF once occurred naturally:

Cyclical steep land agroecosystem

Deforestation has been particularly severe on the Pacific-facing slopes of El Salvador, Honduras and Nicaragua. Here, MTDF has been largely reduced to an agroecosystem consisting of a shifting mosaic of fields, fallows, pastures and small secondary woodlands. Aerial photographs of the agroecosystem of southern Honduras show that the area of fallow in the landscape is progressively reducing. These shrinking fallow areas are secondary in nature and different in structure to mature dry forest. However, in the Central American agroecosystem they may include the only remaining areas of closed canopy vegetation left in the landscape, and are therefore important as habitat for fauna and as a source of the 'seed rain' on which the regeneration of dry forest trees depends. As will be seen in Chapter 4, this landscape contains large amounts of tree material, in fallows and woodlands, and also as scattered trees, live stumps and seedlings in fields.

Extensive, apparently intact forests

In the western and southern Mexican states of Jalisco, Michoacan, Guerrero and Oaxaca, large expanses of forest remain. Although apparently intact, in reality much of this area may at some time or other have been subjected to temporary clearance for the establishment of small agricultural plots, or to grazing and browsing by livestock. In a number of areas these forests currently face serious threats from agriculture, ranching, roads and tourism development. It has been estimated that half of Mexico's MTDF has been severely altered or converted to other uses (Trejo and Dirzo, 2000).

Commercial lowland agriculture

Substantial areas of the coastal plains and interior valleys of both Central America and Mexico are dominated by large land holdings on which commercial agriculture (such as melon and sugarcane production) is practised. Because of the flat topography and the value of these crops, most of the original tree cover, including stumps, has been mechanically removed. Trees are mostly confined to fence lines where opportunities for regeneration are limited and, in the case of sugarcane plantations, they are subject to damage from fire.

Ranch lands

Other parts of the coastal plains and interior valleys of Mexico and Central America are dominated by poorly managed cattle pasture. Such pastures are also present on hill lands, such as those of the dry zone of north-western Costa Rica. In some areas, large shade trees of species such as *Enterolobium cyclocarpum* and *Albizia saman* are common, some of which may be remnants of the original forest cover, or may be natural savanna species that now benefit from forest conversion. Other lowland pastures are dominated by small, scattered *jícaro* trees (*Crescentia alata* and *C. cujete*). Where grazing is either not practised or is carried out at very low intensity, there is dense natural regrowth of shrubby species such as *Caesalpinia coriaria*.

At the species level, there is concern that many MTDF trees have suffered severe declines in their numbers and in the genetic diversity of their populations. In some cases mature MTDF trees scattered through the agricultural landscape have been described as ‘the living dead’ (Janzen, 1986), as the conditions in the degraded landscape around them appear to make it virtually impossible for them to regenerate.

Current threats to MTDF trees and forests

There is no precise information about which MTDF species have already been lost as there are no old botanical checklists to compare against. There are a number of processes, however, that are having a far-reaching impact on the current range and composition of the MTDF.

Smallholder agriculture

The initial clearance of much of the original hillside forest in the MTDF zone was carried out by small farmers, marginalised from the fertile lowlands by ranching and commercial agriculture. Over much of dry zone Central America, clearance of original forest is now largely a thing of the past as almost all of the landscape has already been converted to a cyclical agroecosystem. However, there is a progressive reduction in the fallow area in the landscape of southern Honduras, due to growing population pressure that is yet to be fully compensated by emigration trends (see Fig. 2.2).

Cattle

Cattle ranching has led to the elimination of large areas of forest and fallow, in both Mexico and Central America. Once pastures are established, tree regeneration tends to be hampered both by grazing and by the practice of burning pasture to encourage new growth and eliminate ticks. The scale of ranching in Central America has been largely tied to US demand for cheap beef (De Walt, 1983). This reached its peak in the mid–late 20th century but subsequently became less viable because of a slump in US demand, leading to a reduction in the cattle herd and the abandonment of many ranches, for example in the Guanacaste area of Costa Rica. However, ranching continues to be an attractive option for many farmers, especially under conditions of labour shortage resulting from the progressive emigration of the economically more active sectors of the population. It requires limited investment of labour and other resources and permits the assertion of property rights over large areas of land. Capital held in the form of cattle is easily converted into cash and, despite declines in export markets, prices for beef tend to be subject to less annual variation than most other crops.

Fire

Fire is commonly used as a tool for resource management. In staple grain production systems, it is often used as a site preparation method, especially in areas with thorny vegetation and where labour is scarce. As described above, in ranching areas fire is used to regenerate pasture and eliminate ticks. The balance of opinion amongst ecologists is that fire is not a natural part of MTDF ecology. It is now common for protected area managers to treat all fires as unnatural and eradicate them (Janzen, 1986). Support for this comes from Puerto Rico where Murphy and Lugo (1986) report no natural fires in tropical dry forest during 50 years of protection. However, not all authors are convinced that natural fires never occur in MTDF (Middleton et al., 1997; Otterstrom and Schwartz, 2006). What is certain is that human induced fires, occurring at frequencies far greater than anyone would suggest for wildfires, have had a drastic and, at least from the point of biodiversity, detrimental effect on MTDF biota. Frequent burning affects the natural species composition by eliminating some species and favouring others (Otterstrom and Schwartz, 2006) and alters the course of ecological succession.

Timber extraction

The high quality and value of the timber of many MTDF tree species (such as *Bombacopsis quinata, Cedrela odorata, Cordia alliodora* and *Swietenia humilis*) means that they are commonly felled, for use in construction and furniture manufacture. Past over-exploitation of some species for industrial purposes has reduced the standing value of this resource (Gordon et al., 2005). As will be seen in Chapter 4, the demand for timber can in some cases motivate farmers to nurture trees as a source of income. However much of the felling that takes place is in the form of poaching, especially in areas where individual access rights are not well defined, and this can lead to the progressive degradation of tree populations. The value of other forms of tree product can at times also contribute to the degradation of tree populations. In some areas of coastal Oaxaca, for example, populations of *Amphyteringium adstringens* are apparently being over-exploited by local people because of the demand for its bark, which is sold for medicinal use. This case is examined in more detail in Chapter 5.

Commercial agriculture

The expansion of commercial crops, such as cotton, sugar cane and melons, has played a significant role in the elimination of large areas of dry forest in southern Honduras, as is evident from historical records and aerial photographs of the coastal plains. Similarly, local people report that forests on the coastal plains at the western extremity of coastal Oaxaca were cleared with Government assistance in the middle of the 20th century. Today, much of this area is used for the production of citrus fruits. In both countries, the threat of the expansion of commercial agriculture is now largely in the past, as virtually all of the forest on flat land suitable for mechanised cultivation has already been cleared.

Tourism development

The development of tourist resorts has contributed to deforestation in Mexico (Ceballos and

García, 1995), particularly along the coast. Some parts of the MTDF region have high potential for ecotourism, which can – if managed appropriately – serve to motivate conservation, to generate income for local communities and thereby to counterbalance some of the negative impacts of resort-based tourism. Despite the existence of some promising examples, however, the full potential of ecotourism in the region is far from being realised.

The people of the dry forest

Historically, the natural conditions of dry forest areas made them more attractive for settlement than the disease-ridden, difficult to clear forests of the humid tropics. Significant numbers of people lived throughout the Mesoamerican dry forest zone in pre-Columbian times (Newson, 1992) and Berrío et al. (2006) trace human impact on western Mexican dry forest back 2,700 years.

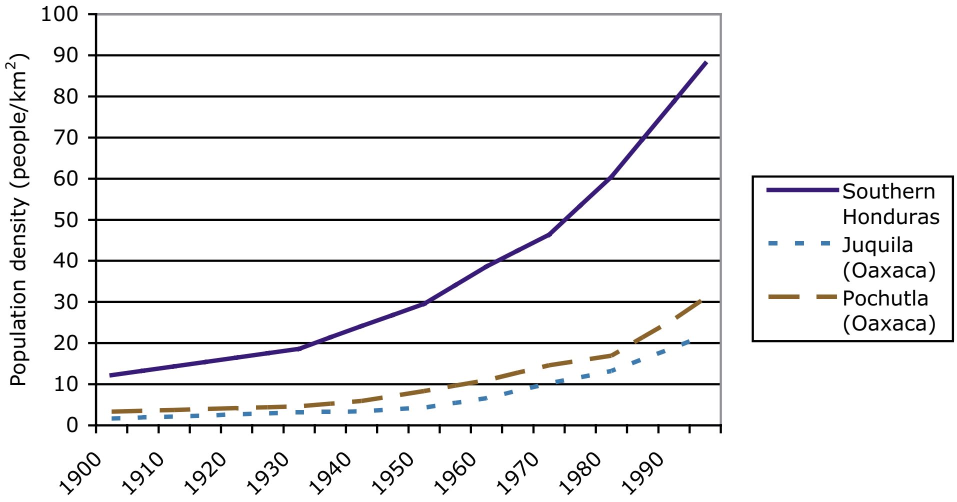
The Spanish conquest led to a population collapse of staggering proportions among the area's indigenous people, especially on the coastal and inland lowlands of Central America, because of a combination of diseases, slavery and excessive demands for tributes (Newson, 1992). This phenomenon was rather less severe in southern Mexico, due partly to a recognition by the colonial authorities of the need to ensure the survival of a labour force.

Most of the indigenous population of the Central American dry forest zone, who managed to survive the conquest, were obliged to leave the lowlands to make way for the cattle and cash crops introduced by the Spanish settlers. These patterns of economic activity persist to the present day. As a result, land tenure in southern Honduras and neighbouring parts of Central America remains highly polarised between large landholdings on the fertile plains and small farms on the surrounding less fertile, dissected slopes. Land reform initiatives in the 1960s and 1970s in Honduras were largely ineffective because of inadequate provision of support to the beneficiary groups. In neighbouring Nicaragua much of the reform undertaken by the Sandinistas during the 1980s has since been reversed.

In southern Mexico, by contrast, very extensive areas of land are held under communal tenure arrangements. This is due to the less complete eradication of indigenous culture by the Spanish conquerors, and the much more effective and universal land reform process of the 1930s, following the Mexican revolution. As will be shown in later chapters, this communal tenure is linked to communal decision-making structures, even though some communal land is, in reality, under *de facto* private tenure.

Population growth in Central America has been exponential, particularly during the 20th century. Southern Mexico has lower population densities but similarly high growth rates. Figure 2.2 shows trends in population densities in southern Honduras and in the two Districts of Juquila and Pochutla, which are at the heart of the dry forest zone of the Oaxacan coastal region in Mexico. These growth rates occur despite high levels of out-migration to the lowlands, the cities and – especially in southern Mexico – to the better off states of northern Mexico and to the United States.

Figure 2.2 Trends in population densities in southern Honduras and the Oaxacan coast of Mexico



Sources: DGECH 1993, Rodrígez Canto 1995, Stonich 1993.

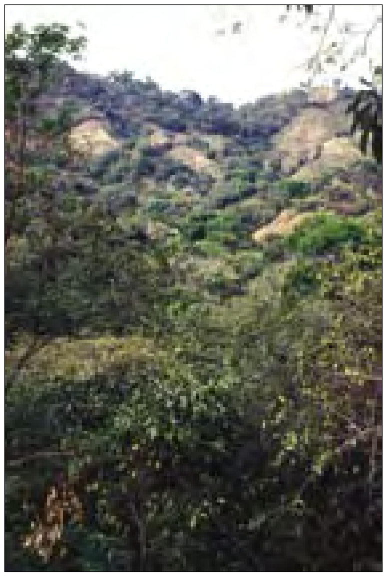
Poverty in the Mesoamerican dry zone

Rural areas in both of the countries included in this study, Honduras and Mexico, are characterised by high levels of poverty, food insecurity, low levels of income and substandard living conditions (see Box 2.1). There are strong links between the level of poverty and the condition and management of natural resources. This is particularly true in the dry zone. On the hills, land tenure inequities and population growth mean that productive land is in short supply. At the same time, the ways in which many farmers manage their land and vegetation,

Box 2.1. Some indicators of poverty in the Mesoamerican dry forest zone

- In 1999, 75% of rural households in Honduras were below the poverty line and 61% were in conditions of extreme poverty.
- The average Human Development Index of Honduras stood at 0.664 in 2004. The figures for the departments of Choluteca and Valle, included in this study, were 0.627 and 0.649 respectively.
- The average Human Development Index in Mexico was 0.803 in 2004, compared to 0.734 in Oaxaca.
- In 14 dry forest municipalities of southern Honduras, more than 40% of households were found in 1988 to have more than 3 basic needs unsatisfied.

Sources: Republic of Honduras (2001), UNDP (2006a, 2006b) such as burning fields prior to sowing, lead to problems including soil fertility loss, surface crusting, reduced rainfall infiltration and increased evaporation of soil moisture. This exacerbates pressures on the available land and increases the vulnerability of agricultural production, and therefore livelihoods, to variations in rainfall cycles. In addition, limited advantage is taken of the potential of the products and services provided by trees and forests to contribute to broadening the narrow income base which characterises much of the rural population (Barrance, 2000; Benítez et al., 2005; MacQueen et al., 2001).



Steep hillsides in southern Honduras make both agriculture and access to markets difficult

These problems are made worse in many areas by poor physical access to markets, as a result of broken topography and limited infrastructural development. Farm families' ability to participate in markets and to take advantage of technological developments is further constrained by their typically low levels of education and, particularly in Central America, their low levels of organisation.

Existing conservation approaches in the MTDF

Conservation initiatives to date have been limited in their extent and effectiveness. A major challenge is to reconcile conservation with the development needs of the population of the MTDF zone. The different approaches that have been applied to the conservation of the MTDF are reviewed below.

In situ conservation

In situ conservation involves the conservation of flora or fauna in the location *and the ecosystem* (in as natural a state as possible) in which they naturally occur. This normally requires the declaration of reserves or protected areas, where human activities are restricted to a greater or lesser extent. The World Conservation Monitoring Centre estimates that only 4.3% of the remaining deciduous and semi-deciduous broadleaved forest in Central America is currently conserved *in situ* in protected areas (WCMC, 2004). In Box 2.2 we describe some of the most significant dry forest protected areas established to date. In general, the establishment of protected areas has been hampered by the high levels of pressure from farming activities, which have made it impractical to take significant areas of land out of production.

Constraints to *in situ* conservation have been least significant in the dry north-west of Costa Rica. Here, the abandonment of large cattle ranches due to falling beef prices in the 1980s freed large areas of land for forest regeneration and restoration. However, even here, some of the land affected did not become available for conservation activities until the 1990s or faced competition from alternative land uses, such as rice production. In certain areas, conflicts arose with local people who were to be affected by protected area establishment.

Box 2.2 Some important dry forest protected areas in Mesoamerica

The **Chamela-Cuixmala Biosphere Reserve** in the western state of Jalisco in Mexico is one of the best preserved areas of dry forest in the region. Threatened by a tourism development scheme, the area was effectively protected by a legal and public campaign highlighting its biological value and uniqueness (Ceballos and García, 1995). It covers 13,142 ha and includes low deciduous forest and medium semi-deciduous forest, on land acquired from a few large landholders. The strictly preserved core zone, to which access is highly controlled, makes up 70% of its area. In the remaining buffer zone, various activities compatible with the maintenance of forest cover are permitted, subject to a high level of control.

The terrestrial part of the 6,000 ha **Huatulco National Park** in Oaxaca, Mexico, (Gordon et al., 2006) protects dry forest adjacent to the recently developed Bahías de Huatulco tourist resort. The forest is largely secondary and had previously been used by local communities. When the land was expropriated by the federal government for the establishment of the tourist resort, the communities were compensated with land elsewhere in the municipality, but at significant financial and social cost to them. One community which refused to be relocated remains within the park boundary.

The **Chacocente Reserve** on the southern Pacific coast of Nicaragua (Gordon et al., 2006) comprises 14,800 ha of tropical dry forest, zoned into core and buffer areas, as well as important turtle nesting beaches. In what is one of the poorest areas of the region, the park management has been faced with various conflicting claims on forest products from local landowners and farmers, which are incompatible with conservation to varying degrees. Considerable investment is planned, both in and around the park, to establish effective management that respects private property and the need of local people to utilise resources in support of their livelihoods.

One of the longest established and most important protected areas in the region is the 88,000 ha **Guanacaste Conservation Area** (GCA) in the north-west of Costa Rica, which brings together a number of smaller protected areas within a matrix of connecting agricultural landscape. Central to the management approach here is the restoration of dry forest in former pasture areas, through the establishment of 'nuclear' seed trees and the suppression of fire (Janzen, 1986). The **Tempisque Conservation Area,** in the same region of Costa Rica, also contains large areas of intact dry forest in a number of protected areas such as the Lomas Barbudal Biological Reserve and the Palo Verde National Park.

Experiences in some of the dry forest areas of Mexico have been different. Here, relatively low population densities and the existence of communal tenure and community-based structures for natural resource management have allowed large areas of forest to survive (see Chapter 5). Initiatives on the part of federal authorities to establish protected areas have tended to be treated with mistrust or as impositions (Castillo et al., 2005), but there have been important advances in the establishment and management of community-based protected areas, as in the case of the communal lands of Santa María Huatulco in southern Oaxaca, Mexico (Box 5.2).

Integrated Conservation and Development Projects (ICDPs)

The concept of ICDPs evolved as a result of the limited success of conventional approaches to protected areas, based on exclusion and regulation, in conserving biodiversity in developing countries (Wolbers, 1998). ICDPs aim to protect biodiversity by providing local communities, especially those living in or around protected areas, with tangible incentives for conservation management (Sekhran, 1996). Examples of ICDPs in Central America include the Community Sustainable Self-Development Project in the Buffer Zone of Piedras Blancas National Park and Golfito Wildlife Refuge, Costa Rica, and the Mayan Forestry Action Plan in Guatemala. This strategy has had varying degrees of success (van Schaik and Rijksen, 2002). In the Maya Biosphere Reserve in Guatemala, for example, where sustainable development activities are intended to provide an economic alternative to deforestation, the approach has encountered a number of problems. Implementation has been hampered by complexity, poor understanding of biophysical considerations, limited empowerment of local people to resist external threats and possible unintended exacerbation of threats to biodiversity (Brown, 2002). Such difficulties have led to criticism of the ICDP concept and a restating by some of the need for strictly protected areas (Terborgh et al., 2002).

Ex situ conservation

Ex situ conservation involves the removal of flora or fauna from the location where they naturally occur, and their conservation either in a dormant state (e.g. as tissue or seed) or in breeding populations (e.g. in zoos or seed orchards). During the 1980s and 90s, much work was carried out in Central America in exploring and collecting the genetic resources of dry forest tree species, such as *Bombacopsis quinata* (CONSEFORH, 1998a), *Cordia alliodora* (Boshier and Lamb, 1997), *Gliricidia sepium* (Stewart *et al.*, 1996) and *Leucaena* spp. (Hughes, 1998). Breeding seed orchards were established, with the double objective of conserving the species' genes in isolation from the threats that they face in the wild, and of producing high performance seed to be used in forestry and agroforestry projects both within and outside the region. In practice, these two objectives have proved difficult to reconcile, as conservation goals would normally require the maintenance of patterns of genetic diversity in as near a natural state as possible, whereas on-station tree improvement involves their modification, through processes of artificial selection (Barrance, 1997). Such orchards are also expensive to establish and maintain, leading to significant doubts about their sustainability, given the resource limitations typically faced by the national forestry institutions which manage them.

Circa situm conservation

There is growing evidence that the continued conservation status of many globally important Mesoamerican tree species is largely due to the protection, planting and management of trees by local farmers in the heavily altered agroecosystem which is all that remains of the original MTDF throughout much of Central America. For example, large proportions of the populations of many of the 22 known species of *Leucaena* in Mesoamerica are found in disturbed agroecosystems rather than in intact forest (Hughes, 1998). Although there is increasing recognition of the potential of MTDF tree species to contribute to farmers' livelihoods through inclusion in forestry and agroforestry programmes, little attention has as yet been paid to promoting the *circa situm* protection of trees in agroecosystems specifically as a strategy for biodiversity conservation (CONSEFORH, 1998a and 1998b).

Ecological restoration

The *in situ* conservation carried out in the Guanacaste Conservation Area in Costa Rica has been complemented by the restoration of elements of tropical dry forest on former pasture land, through a combination of practices including the planting of nuclear seed trees to promote seed dispersal, and the suppression of fire (Janzen, 1986) (see Box 2.2). In Costa Rica this was made possible by the abandonment by ranchers of large areas of pasture. In the smallholder landscape of the southern Honduran hills, however, this practice is less applicable because of the limited availability of land that can be taken permanently out of production.

Biological corridors

The ability of fauna and flora to move and breed between areas of habitat is important in increasing the effective size of their habitats and promoting the diversity of populations. Recognising the importance of regional action on conservation in Central America, a relatively small physiographic unit with many common elements (Campos Arce et al., 2005), the Mesoamerican Biological Corridor (MBC) was established in 1997. The MBC promotes the concept of 'connectivity' at a regional level, and emphasises the compatibility between conservation and sustainable development in the landscape that separates protected areas (Miller et al., 2001). The MBC aims to establish a number of parallel regional corridors, one of which follows the dry zone of the Pacific coast of Central America. A major challenge facing this initiative is how to ensure that the protected areas identified for inclusion in the MBC actively contribute to connectivity, and that they enjoy sufficient resources to avoid becoming 'paper parks' (Utting, 1993).

Conservation through use

Conservation through use (CTU), the theme of this book, is by no means a new phenomenon in Mesoamerica, and in fact underlies many of the above approaches. The human populations of the region have for generations depended for their livelihoods on a range of products and services obtained from trees and forests. Local communities also commonly protect trees around water sources and nurture or plant certain species that yield valued products. As noted above, the *circa situm* conservation by farmers of many species of *Leucaena* is largely motivated by their perceived use value, for example, in the case of *L. esculenta*, as a source of edible pods (Hughes, 1998). However, some initiatives in the region to promote NTFPs as a means of motivating local producers to conserve their forests, have raised concerns over the long-term impacts on the resources in question. For example, the extraction of dyes from the Maya Biosphere Reserve in Guatemala (a humid area of Mesoamerica) is predicted to lead to eventual over-exploitation of some species (Goulda et al., 1998). To date little attention has been paid to determining, or actively promoting realisation of, the potential contribution of CTU to the conservation status of trees and forests in the MTDF, or its implications for farmers' livelihoods.

Rural development initiatives related to MTDF trees and forests

There have been a large number of initiatives in the region that have sought to promote the livelihoods of local people through the incorporation of MTDF trees into farming systems and plantations, or through the sustainable management of natural forests. The results have been mixed. Table 2.1 summarises the results of a selection of early reforestation projects.

Table 2.1 Results from a selection of tree-based projects

Case study	Main components	Key results
Reforestation using incentives in the Hojancha region of Costa Rica	• Establishment of plantations to generate income and take advantage of Government incentive scheme	• Large numbers of trees were established • Some producers managed to sell trees and seed, but few managed to sell the products of thinnings • Internal rates of return varied between 16.4 and 27.1% • The nurseries were an important source of employment and income • The system was robust to price variations • Doubts remain about how benefits were distributed • Participation and decision-making were dominated by men
Agroforestry support to resource poor rural communities in El Salvador	• Establishment of pure plantations and association of trees with soil conservation • Fallows enriched with *Gliricidia sepium* • Alley cropping, live fences and contour planting	• Levels of adoption of technologies ranged between 4 and 17% • The profitability of the tree/crop combination systems was low • Taungya and improved fallow systems were highly profitable and robust to variations in price, costs and yields
COHASA I in Honduras	• Establishment of communal nurseries • Establishment of forestry plantations	• Nurseries producing timber and fruit trees were managed as businesses by local people on a long-term basis • 1,400 ha of trees were established • Many producers lost interest in establishing plantations once incentives were suspended

Source: Current et al., 1995

A number of factors have been identified as affecting the success of tree management projects in the region, including the following (Barrance and Hellin, 2003):

- **Use rights:** to be interested in planting trees, farmers must be sure of their rights eventually to obtain benefits from them. This does not necessarily mean that farmers need to possess formal title to the land. In some cases, over-restrictive laws may reduce farmers' confidence in their rights to use and manage trees.
- **Multiplier effect:** many projects focus their extension efforts on particularly active 'model farmers', in the hope that these will communicate technologies to others, leading to a progressive multiplication of the numbers of farmers applying the technologies. In practice, this effect has often been limited, either because of a lack of commitment

and/or capacity on the part of the leader farmers, or because the technology itself is not appropriate to the conditions and needs of other farmers.

- **Technologies:** many technologies, which have appeared promising in other regions or experimental stations, have failed on farm. Successful technologies must be appropriate in productive, social and biological terms, and must complement farmers' other activities and components of their farms. In addition they must not require small farmers to assume risks that may affect their livelihoods.
- **Incentives:** the provision of economic, fiscal and/or material incentives has in some cases led to high levels of reforestation activity. However, the effects of this strategy have often been short-lived, as farmers may be motivated more by the incentives than by a genuine belief in the technologies, and may abandon them once the incentives are withdrawn.

Many projects have underestimated the potential of native tree species and naturally regenerated tree material. High performing exotic species such as eucalypts, neem (*Azadirachta indica*), teak (*Tectona grandis*) and *Gmelina arborea*, have often been emphasised at the expense of native species, many of which yield high quality, locally familiar products and can be cheaply established through natural regeneration.

In general, uptake by farmers of tree-based rural development activities has been low, in spite of the large amounts of resources invested, for example, in incentives and tree nurseries. At the same time, the full value of native MTDF tree species and forests has not been appreciated (Barrance and Hellin, 2003).

There are exceptions, however. The Lempira Sur project in western Honduras, for example, has had considerable success in promoting the widespread adoption by farmers of a locally-developed management system termed *Quezungual*, which involves the protection and coppicing of naturally regenerated trees in fields and the use of the resulting mulch to conserve soil humidity for crops. This practice, variants of which exist in other parts of Central America, has proved eminently compatible with the needs of small hillside farmers. It requires minimal investment of labour and other resources, and addresses directly the scarcity and unreliability of soil moisture, one of the most crucial factors affecting staple grain production (Clercx and Deugd, 2003). The extensive plantations of *Bombacopsis quinata* in Costa Rica represent another of the few cases in the region in which a native species has been subject to widespread planting by farmers.

There have been only a few attempts to promote rural development through sustainable forest use in the MTDF and even fewer successful experiences. Two cases in Oaxaca are discussed in more detail in Chapter 5. In Costa Rica, meanwhile, there have been successful experiences of raising iguanas for sale in small woodland areas. The conservation benefits of this practice, however, tend to be limited because of the restricted scale and biological importance of the woodlands involved.

3. Case study areas and research methods

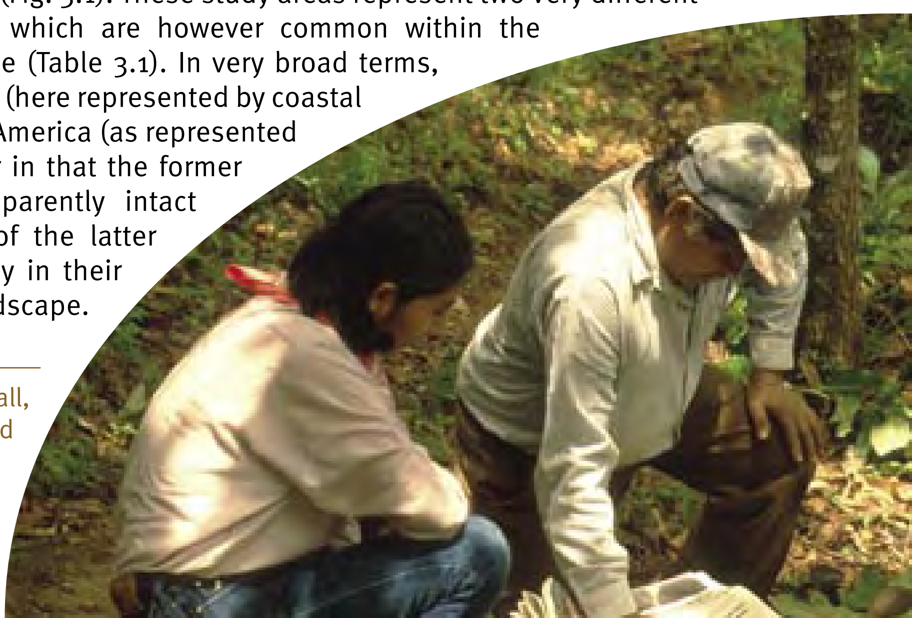
This chapter describes the case study communities and outlines the methods used to investigate the potential of conservation through use in two areas within the Mesoamerican tropical dry forest Zone. Socio-economic research methods were used to understand how local people use and manage their tree resources, while policy studies in both countries provided an overview of the policy context. A rapid botanical survey helped to define which species and sites in the case study areas are of highest priority for conservation.

An integrated research approach

Questions relating to the complex interaction of people and natural resources can best be answered by drawing on some combination of quantitative and qualitative information (Schreckenberg et al., 2005). This research therefore included a number of different components ranging from more qualitative farmer interviews to highly quantitative botanical inventories, and economic studies lying somewhere in between. The key to the effective combination of methods and data lies in the iterative relationship between descriptive (usually more quantitative) and explanatory (more qualitative) approaches (Holland and Campbell, 2005). In practice this meant that the components were carefully phased, so that the results of one strand could feed into another. There was a continuous flow of information between team members involved in the different research components throughout the fieldwork period. Following completion of the fieldwork, the resulting biological, social and economic information was brought together to analyse the conservation significance and potential of the tree and land use management practices identified. As a development research project, there was a strong emphasis on achieving buy-in by the eventual users of the research results and on capacity-building of partners throughout.

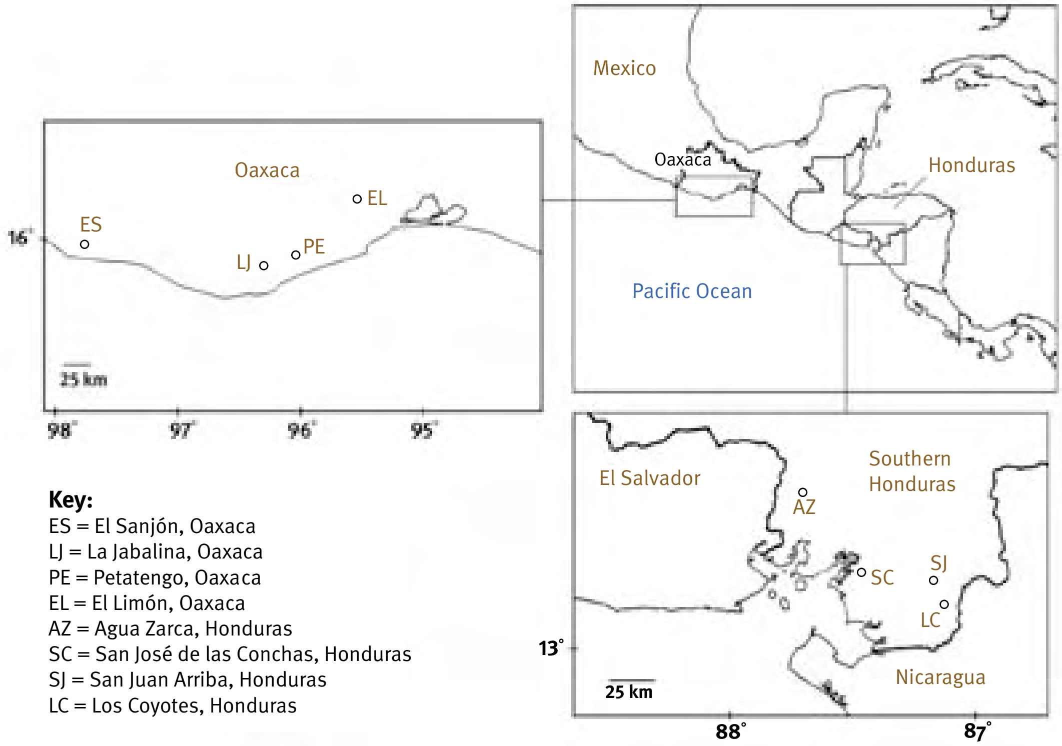
Study areas

The research focused on the two case study areas of southern Honduras and the coastal zone of Oaxaca state, Mexico (Fig. 3.1). These study areas represent two very different sets of conditions, both of which are however common within the Mesoamerican dry forest zone (Table 3.1). In very broad terms, the dry forest zones of Mexico (here represented by coastal Oaxaca) and most of Central America (as represented by southern Honduras) differ in that the former contains large areas of apparently intact forest whereas the forests of the latter have been converted virtually in their entirety to an agricultural landscape.



The botanical team at work – in all, some 260 land units were sampled for tree diversity and over 9,000 records (observations of trees) were taken

Figure 3.1 Location of case study areas in southern Honduras and the coastal zone of Oaxaca state, Mexico



Another significant difference, of potential relevance to whether and how CTU functions, is that large areas of land in the Mexican dry forest area are held communally, whereas tenure in most of Central America is individual in nature. What the two study areas have in common is that they both contain institutions and organisations interested in participating in, and learning from, research on CTU.

Study communities

Four study communities were selected in each of the two case study areas (see Box 3.1). Between them, these represent a cross-section of the diverse physical and social conditions found in each study area. Among the factors taken into account in selecting the communities were the following:

- Altitude, ranging from sea level to about 500 metres above sea level;
- Rainfall, with less than 10% falling in the dry season months of November to May;
- Vegetation cover, ranging from lowland pastures and fruit plantations, through mosaics of maize fields and fallows, to extensive areas of largely intact forest;
- Production systems, including the subsistence production of maize, low intensity coffee production, cattle ranching at different scales, and fruit production in both homegardens and plantations;

Table 3.1 General characteristics of the study areas

	Southern Honduras Specifically, the coastal plains and foothills of the Departments of Choluteca and Valle, around the Gulf of Fonseca. These are typical of the Pacific drainage of much of Central America.	**Coastal Oaxaca** Specifically, the coastal region of the south of Oaxaca, between the Sierra Madre del Sur and the Pacific Ocean as far East as the western limit of the Isthmus of Tehuantepec.
Forest condition	Dry forest almost completely converted to an agroecosystem dominated by cyclical basic grain cultivation, ranching and export agriculture, with scattered trees and fragmented secondary woodlands	Large areas of apparently intact dry forest, but significant areas converted to shifting and permanent agriculture
Social conditions	High levels of poverty, low levels of community organisation	High levels of poverty, well developed organisational structures
Tenure	Almost exclusively private (*de jure*/*de facto*) and individual; highly polarised between large commercial holdings on the coastal plains and smallholdings on the surrounding hills, much renting	Largely communal or *ejidal*, but with significant areas affected by enclosure and *de facto* individual usufruct
Population and culture	Almost entirely *mestizo*, and under exponential growth despite significant emigration	Largely *mestizo* (in contrast to many inland areas of Oaxaca and the Isthmus of Tehuantepec), with some indigenous cultural characteristics. Also showing high growth rates, but much lower population densities than southern Honduras

- **Social organisation**, ranging from communities where farmers operate largely as individuals, through *ejidos*, to highly organised agrarian communities;
- **Culture**, ranging from *mestizo* communities to those made up of immigrants from indigenous communities elsewhere, who still maintain indigenous cultural traits and language.

Socioeconomic survey

The aim of the socioeconomic research was to find out how local people perceive, manage and use trees and forests, and how this relates to their farming systems and livelihoods. Thus it attempted to assess the *local* importance of dry forest resources, while the botanical research focused on *global* importance. As farmers' livelihoods and decision-making processes are complex, semi-structured interviews were used to allow open-ended discussion and exploration of themes relating to tree management. These were combined with visits to farmers' fields at different moments in the agricultural calendar.

Box 3.1 The case study communities

Southern Honduras

San Juan Arriba: A steep-land community in the wetter east, with relatively good access to markets and off-farm employment. Many farmers grow coffee, but this is declining in importance. Much fruit is produced, and marketed through intermediaries. There are many interventions by external organisations.

Agua Zarca: A steep-land community, in the drier west, with poor access and almost exclusive dependence on staple grain production. Agua Zarca is largely bypassed by external organisations.

San José de las Conchas: Near the coast, its lands cover both a hill outlier and coastal plains. San José was established under the agrarian reform programmes of the 1960s and 1970s. Access to off-farm employment is good, and there is much cattle raising. There is relatively little external intervention.

Los Coyotes: In the wetter east, on largely steep land, but at relatively low altitude. There is much trade in timber and firewood to nearby towns and good opportunities for off-farm income. A food-for-work based forestry project worked with a farmers' cooperative in the community in the 1990s.

Coastal Oaxaca, Mexico

El Sanjón: On the coastal plains in the wetter west, this community has good soils and market access. The communal lands are almost entirely individually managed, and are mostly used for lemon and coconut plantations and cattle. A local NGO is promoting 'cellular reserves' in patches of secondary woodland.

La Jabalina: This includes several scattered hamlets in the communal lands of Santa María Huatulco, where a local NGO is facilitating community-based resource management planning. Many people have left to live nearer to the coast road and the Bahías de Huatulco tourism complex. Much communal forest remains.

El Limón: The only case study community which is an *ejido*, El Limón is in the drier east, near the markets of the Isthmus of Tehuantepec. It has received very little NGO or project support.

Petatengo: Part of the communal lands of Santa María Xadani, Petatengo includes both communally and individually managed land. A local NGO is promoting the sustainable harvesting and commercialisation of non-timber products and handicrafts from the community's forests.

A target sample size was set of 20 farm households per community. A total of 159 farmers were interviewed in the eight communities (Table 3.2). Selection of the interviewees began with a participatory wealth-ranking process (Pretty et al., 1995), in which key informants defined stratification criteria and categorised the members of their communities accordingly. Among the criteria most commonly chosen by the participants to describe economic status were the size of land holding and the number of cattle. Within each wealth category, a sample of farmers was randomly selected, approximately proportional in number to the relative magnitude of the category in the community as a whole. Those interviewed thus represented the whole socioeconomic spectrum, ranging from landless labourers to large landowners.

Table 3.2 Number of families sampled relative to community size

Community	Sample size (families)	Total community size (families)	Sampling intensity (%)
Southern Honduras			
San Juan Arriba	20	160	12.5
Agua Zarca	20	62	32.2
San José de las Conchas	20	150	13.3
Los Coyotes	19	57	33.3
Coastal Oaxaca, Mexico			
El Sanjón	20	30	66.7
La Jabalina	20	32	62.5
El Limón	20	43	46.5
Petatengo	20	130	15.4

A basic set of household data (land holding size, types and sizes of land unit, number of years in the community, etc.) was collected for each family in the sample. This was followed by an interview following a roughly predetermined structure. At the same time, the researchers encouraged the farmers to elaborate further on any particularly interesting themes that arose during the course of the conversation.

After the interviews, the researchers grouped the farmers' comments by theme (for example, reasons for protecting trees in fields and preference criteria for selecting species for different uses) and by the tree species that farmers had listed in different contexts (for example, species most valued for different uses, most protected in fields and most planted). This information, farmer by farmer, was entered into a database for quantitative and qualitative analysis.

In addition to individual interviews and field visits, focus group meetings (17 in total) were held with invited groups of community members. These meetings used a combination of open discussion and visual tools (such as matrices and timelines) borrowed from Participatory Rural Appraisal to shed further light on specific themes that had emerged in the course of the individual interviews, such as particular production systems, organisational structures and aspects of tenure.

Two more detailed economic studies were carried out to understand how existing economic motivations to manage or maintain trees are likely to impact on on-farm tree biodiversity, and how the latter is likely to change in response to economic pressures in the future. In Agua Zarca and Los Coyotes, Honduras, a comparison was made between larger less-intensive (longer fallow period) and smaller more-intensive (shorter fallow) farms (Richards, 2000). In El Limón and Petatengo, Mexico, the focus was on understanding the impact on tree biodiversity of agricultural intensification and the trend away from communal crop management (Davies et al., 2000). In both cases, household surveys were complemented by discussions with individual key informants, focus groups and secondary data.

Policy context

The implications of existing laws, policies and institutional structures for the conservation status of the dry forest were analysed in each country by means of a literature review of present and past laws (and the institutional arrangements which they specify) and policy trends (Díaz Arrivillaga, 2000; González and Beltrán, 2000). Interviews were conducted with key informants at a number of levels, from central government through to community representatives. The methodology, together with an initial list of laws and policies to be analysed and actors to be interviewed, was discussed and refined through initial 'scoping' meetings in each country, attended by representatives of a range of governmental and non-governmental institutions.

Botanical survey

The botanical work was carried out in collaboration with herbaria in Honduras and Mexico and local NGOs in both countries. As seen in Chapter 2, the MTDF contains large numbers of tree species. It was therefore necessary to devise a practical, cost-effective yet objective method for defining and comparing conservation priorities among such large numbers of species. The botanical methodology progressed in three stages (Gordon et al., 2004):

(i) Survey and identification of species in different sites and land uses

The botanical team began by establishing a draft checklist, based on published sources and herbarium specimens, of all tree and shrub species known to occur in the study areas. They then carried out detailed surveys ('checklisting') of the tree and shrub species in the land units managed by farmers who had been interviewed by the socio-economic team. These included fields, fallows, pastures, homegardens, coffee plantations and woodlands. They also surveyed a selection of woodlands elsewhere throughout each of the study areas. These forests were not selected at random but were biased to maximise geographical coverage and include larger forest fragments. A slightly modified version of the plotless, rapid botanical survey methodology described by Hawthorne and Abu-Juam (1995) was used because of its speed and efficiency in a structurally diverse landscape (Gordon et al., 2004). This form of sampling is relatively simple, and Gordon and Newton (2006a) provide an overview of the merits of different sampling methodologies suitable for this forest type.

Each of the trees (above 2.5 cm in stem diameter) found at each site was identified to species level, by comparing them with samples held in national herbaria. Species identification in tropical countries is time and resource consuming, and should not be underestimated when planning. Local people always accompanied the botanical team, enabling them to link vernacular names to scientific names. This in turn was of great value to the socio-economic teams in interpreting and analysing the information provided to them by farmers in different communities on the use and management of different species.

(ii) Assigning species to conservation categories based on their geographical range

A number of criteria can be used to determine conservation priorities, including geographical range, threat and trends in population numbers, as used, for example, in the International Union for Conservation of Nature (IUCN) Red Lists.[2] The simplest and most objective criterion for assigning conservation priorities at a species level, when the number of species to be assessed is large, is their geographic range. This method assumes that the narrower a species' geographic range, the more vulnerable it is to extinction as a result of local phenomena and, in this respect, is similar to the 'area of occupancy' and 'extent of occurrence' parameters used in IUCN categorisations (IUCN, 1994).[3] Other factors could be taken into account, such as population numbers and structure, economic pressures and rates of habitat loss, but these are more complicated and demand data that are available for only a few species. It is impossible to assess large numbers of species in this way. For most of the 600 or more species we dealt with, such information was simply not available, whereas information on geographic range was easily compiled from herbarium collections.

The range of each species was estimated principally on the basis of herbarium specimen data, but also through the use of monographs, reliable checklists (e.g. Reyes-García and Sousa, 1997) and on-line databases such as w³Tropicos.[4] Table 3.3 presents the key used for assigning species to one of four conservation categories, from Category A for species with the most restricted ranges, to Category D for species too widely distributed to be of conservation concern.

Unidentified specimens (less than 10% of the total encountered) were not included in the analysis, with the exception of those specimens, which it was considered were highly likely to prove to be previously undescribed species. These were included in Category A. Because of their expertise in plant identification and the information on species distributions they contain, staff of national herbaria (particularly of the Pan-American Agricultural School in Honduras EAP and the National Herbarium of Mexico MEXU) played a crucial role in this research. At least as many person-hours were assigned to identifying botanical specimens and estimating species' range sizes as were assigned to fieldwork.

(iii) Comparison of conservation priority of sites on the basis of bioquality

Conservation strategies may operate not only at the level of particular species, but also at the level of sites or land uses. It is therefore important to assess the relative conservation priorities of sites and land uses, as well as individual species, in order to identify situations where conservation issues need particularly to be taken into account. A rapid and objective way of doing this is to determine the numbers of high conservation priority species present in a given site or land use. This is a measure of 'bioquality' rather than simply the total

2. http://www.redlist.org/ (accessed 26/1/04)
3. Area of occupancy is defined as the area within its 'extent of occurrence' that is occupied by a taxon, excluding cases of vagrancy. Extent of occurrence is defined as the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of present occurrence of a taxon, excluding cases of vagrancy
4. http://mobot.mobot.org/W3T/Search/vast.html

Table 3.3 Key for assigning species to conservation categories

Criteria	Category
Endemic to the Pacific dry forest zone of Honduras or Oaxaca.	A
Endemic to the Mesoamerican Pacific dry forest zone and present in two to four Central American countries/Mexican states	B
Endemic to the Mesoamerican Pacific dry forest zone and present in five to eight Central American countries/Mexican states OR Not endemic to the Mesoamerican Pacific dry forest zone but present in one to four Central American countries/Mexican states.	C
Endemic to the Mesoamerican pacific dry forest zone and present in more than eight Central American countries/Mexican states OR Not endemic to the Mesoamerican Pacific dry forest zone but present in more than four Central American countries/Mexican states.	D

numbers of species present (biodiversity). Bioquality was scored in the form of a Genetic Heat Index (Hawthorne and Abu-Juam, 1995) for each sample site. A detailed explanation of the methodology used is provided in Appendix 1.

Feedback and dissemination

Once the fieldwork and initial data analysis had been completed, feedback meetings were held in each of the study communities. These meetings allowed for presentation and discussion of key aspects of use and management of tree diversity observed in each community, comparison of findings between communities, identification of reported and observed trends, as well as findings specific to the participants' own community or of particular significance for conservation or livelihood support.

Similar information was presented in workshops for members of NGOs, academic and government institutions working in each of the study areas, providing the opportunity for feedback and validation of results and for discussion of the implications of the research for the organisations' work. Workshops focused on how to integrate rural development and biodiversity conservation, and how to collect and use relevant information as evidence for funding proposals and policy development. This included an introduction to the concept of genetic heat, how it is calculated and how such information can help to target conservation resources. It was emphasised that low genetic heat indices for a given location do not necessarily mean that no type of conservation is required, rather that the emphasis, of that conservation should be much more heavily orientated towards local resource use. Information was also disseminated to the general public through six-monthly project newsletters, newspaper articles and radio interviews, while policy-makers were targeted by specific policy briefs.

4. Southern Honduras: Trees managed by and for farmers

In common with much of the Pacific slopes of the rest of Central America, southern Honduras is dominated by a highly disturbed dry forest agroecosystem. In this chapter we show that conservation through use is a reality in this area; many farmers actively protect those trees which they most value, particularly for timber. However this practice depends upon a number of factors, namely: the level of demand for the products and services provided by the tree in question; the inability of farmers to obtain these products and services either off-farm or through purchase; the degree to which the species involved tolerates conditions in the agroecosystem, and regenerates well; the security which farmers feel over their future rights to reap the benefits from the trees; and the effectiveness and flexibility of regulation.

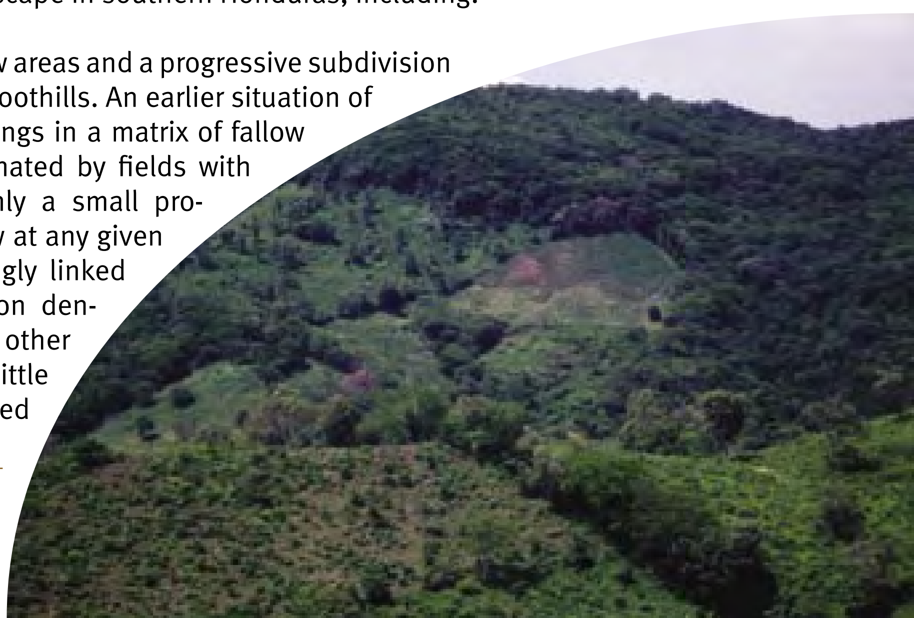
Trends in land use, forest cover and tree populations

The agroecosystem that today covers most of southern Honduras is the product of centuries of disturbance. Before the Spanish conquest, the coastal plains were probably home to tens of thousands of indigenous people, who practised slash-and-burn agriculture and extracted plant and animal products from the forest (Newson, 1992; Stonich, 1993).

The Spanish cleared large areas of the lowlands for ranching and indigo production, followed in subsequent centuries by a series of other export crops, including cotton, rice, melons and sugarcane. Smallholder farmers were marginalised to the surrounding foothills. Combined with exponential rates of population growth, this process has resulted in the almost complete conversion of the original dry forest cover of the foothills to a shifting mosaic of maize fields (*milpas*), fallows (*guamiles*) and pastures (*potreros*).

Farmer interviews, review of census data, field observations and the study of aerial photographs (taken in 1954 and 1983) show that, over the last 50 years, a number of processes have shaped the current landscape in southern Honduras, including:

- A gradual reduction of fallow areas and a progressive subdivision of farms, over much of the foothills. An earlier situation of scattered agricultural clearings in a matrix of fallow has changed to one dominated by fields with permanent boundaries, only a small proportion of which is in fallow at any given time. This process is strongly linked to the growth in population density shown in Figure 2.2. In other parts of the foothill zone, little change can be distinguished over the period.



The southern Honduras agroecosystem

- Organised settlement of upland farmers on large, underused lowland holdings under agrarian reform programmes of the 1960s and 1970s, resulting typically in the conversion of areas of secondary forest, formerly used for extensive grazing, to basic grain production.
- Subsequent transfer of many of the areas affected by the agrarian reform from campesino groups to agro-industrial concerns, for the production of export crops.
- Clearance of significant areas of apparently intact lowland forest, continuing the process begun in colonial times.
- Emigration to urban areas and to the agricultural frontier areas of the humid north coast, especially during the 80s and 90s, a trend which has to some extent slowed the process of farm subdivision.
- Loss of significant areas of natural semi-deciduous coffee shade in the moister areas of the uplands, because of the marginal suitability of this area for coffee production.

Historical trends in the populations of particular tree species are hard to detect with confidence using the data sources mentioned above. However, changes in local people's use of different species can be used (with caution) as a proxy indicator. In a focus group meeting held in the study community of Los Coyotes, farmers described how the levels of use of different species had changed over recent years in response to changes in their availability. They explained how they had virtually ceased to use their preferred timber species, *Bombacopsis quinata*, as its populations in their community had been almost completely depleted over the last few decades. As a result, they are obliged to use a range of other, less highly valued, species (Table 4.1). This suggests that timber resources of some species have been reduced virtually to the point of local extinction due to over-exploitation, whereas populations of other species have remained stable.

Table 4.1 Trends in species use for timber in Los Coyotes, southern Honduras

Species	Past use (%)	Present use (%)	Change in use
Bompacopsis quinata	100	2	Decrease
Cordia alliodora	0	21	Increase
Enterolobium cyclocarpum	0	17	
Albizia saman	0	13	
Swietenia humilis	0	13	
Guazuma ulmifolia	0	13	
Simarouba glauca	0	9	
Albizia adinocephala	0	9	
Cedrela odorata	0	4	

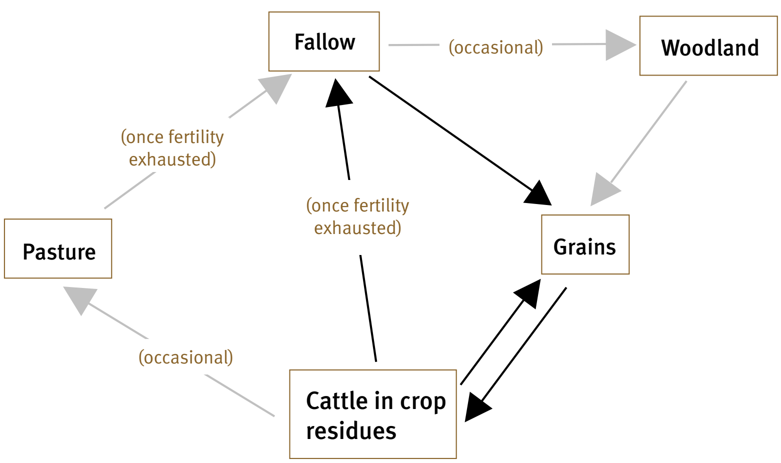
Smallholder agriculture today

The Pacific-facing slopes today are dominated by thousands of smallholders living in small villages scattered throughout the area. Average land holding size in 1993 was 5.2ha (DGECH, 1993). Given the cyclical nature of agriculture and limitations of labour and water, only a small proportion (typically less than 1ha) of this area would normally be under cultivation at any given time. Many of these farmers do not have formal title to their land. In practice, however, individual farmers' rights over particular areas of land, and the trees thereon, are normally recognised and respected by other community members. Smallholder agriculture, which is largely derived from pre-Hispanic practices, is dominated by the rain-fed cyclical production of basic grains (maize, beans and, in drier areas, the more drought resistant sorghum *maicillo*). Agricultural production at the household level is typically limited by the availability of labour.

Cropping cycles usually consist of the following phases, as illustrated in Figure 4.1:

- Manual clearance of fallow vegetation, assisted by burning when labour is scarce and/ or the vegetation is thorny. The generally steep topography means that few people are able to plough.
- Sowing of basic grains using a dibble stick, with two cropping periods for maize (*primera* and *postrera*) during the six-month rainy season. Irrigation is rare, limiting factors being economic resources, steep topography and erratic river flows.
- Introduction of cattle into the fields at the end of each rainy season, to eat the crop residues (*rastrojo*).
- After repeated cropping seasons (the number of which varies according to land availability), the land is either allowed to revert to fallow, or converted to pasture by sowing grasses during the last cropping period. Small-scale farmers tend to have shorter fallows and crop their land more intensively.

Figure 4.1 Schematic representation of a typical cropping cycle in southern Honduras



- Pastures may be maintained for several years, but are usually not permanent; they tend gradually to be invaded by shrubby vegetation and converted into fallows.

Institutional environment

To be successful, conservation strategies such as CTU must take into account the roles and capacities of the institutions charged with supporting rural producers, enforcing regulation and planning and executing conservation initiatives. In Honduras, several different types of institutions and organisations are active in the field of tree use and conservation.

Government

Responsibility for the formulation of environmental policy in Honduras lies with the Natural Resources and Environment Secretariat (SERNA), which is also responsible for the definition and establishment of protected areas. Responsibilities for management and regulation, meanwhile, are split between SERNA and the Institute for Forestry Conservation and Development (ICF), a dependency of the Ministry of the Presidency.[5] SERNA is responsible for controls on the use and management of biodiversity, while the ICF manages the National System for Protected Areas (SINAPH) and enforces controls on protected areas and tree and forest use in general. To date, the ICF, like its predecessor AFE-COHDEFOR, has limited resources and capacity of its own to enforce controls and mainly relies on police checkpoints on the main roads.

Policy formulation, decision making and regulation have to date been highly centralised. Provisions in the Municipalities Law for decentralisation to municipal level have only been implemented to a limited extent, due largely to lack of confidence in the capacities and transparency of municipal governments. Few municipalities have functional Municipal Environment Units.

The interventions of the central Government in rural development and natural resource management have largely been through externally-funded development projects and programmes, under the umbrella of the National Programme for Sustainable Rural Development (PRONADERS), within the Ministry of Agriculture and Livestock. Despite the large amounts of resources that have been devoted to these, results have largely been disappointing in terms of long-term uptake of the technologies promoted and the creation of lasting local capacities (Jansen et al., 2006).

NGOs

A large number of NGOs work in the Honduran dry forest area on issues such as rural development, the provision of basic services and environmental protection. The principal motivation for promoting environmental protection is as an element of sustainable rural development. There is little NGO activity aimed at protecting biodiversity and other global

5. The ICF was provided for in the new Forestry Law, which was approved by Congress in September 2007. It replaces the State Forest Authority AFE-COHDEFOR, which was a semi-autonomous dependency of the Ministry of Agriculture and Livestock (SAG).

values for their own sake, with the exception of those organisations active in protecting the mangroves of the Gulf of Fonseca.

There has been little effective coordination of the activities of NGOs and other institutions. The efforts of different organisations often duplicate each other and may, at times, be in conflict, for example due to differing policies regarding the use of incentives to achieve results (Chenier, 1995).

Community-level organisations

Community-level organisation in southern Honduras is poorly developed. The municipal Government is represented in local communities by auxiliary mayors, who have limited roles and effectiveness. The principal formal entity at community level is the *patronato*, which is largely responsible for overseeing and promoting the community's infrastructure. There is no universal structure formally charged with protecting communities' natural resources, apart from the water committees (*juntas de agua*) where these exist, whose role is to manage communities' water supplies, including the protection of water sources and their protecting vegetation. A number of projects and NGOs have attempted to promote the establishment of community level committees to address environmental issues, but with varying degrees of success. These have in many cases tended to be perceived by community members as exclusively representing those people directly associated with the project or NGO in question. They therefore tend to lack a broad base of support and credibility. In some cases, projects and NGOs have resorted to providing material incentives to community members to encourage them to attend meetings.

Policy and legislative environment

Over the last half-century, the status of the dry forest agroecosystem has been affected directly or indirectly by a range of policies and legislative instruments related to agricultural development, land tenure, decentralisation and forestry:

- *Promotion of export agriculture*. Ever since colonial times, there has been emphasis on developing the productive potential of the lowlands. Support from initiatives such as the US-sponsored 'Alliance for Progress' in the 1960s promoted the development of 'non-traditional' export crops. These policies resulted in the clearance of extensive areas of forest in the lowlands, and marginalised the smallholder population to the foothills, exacerbating pressures on the resources there. Similarly, the expansion of export-oriented cattle ranching in the 1960s (promoted by the World Bank) had the effect of marginalising the production of basic grains by small farmers, thereby increasing the pressure on the available land and forest resources.
- *Agrarian reform*. Under the agrarian reform programmes of the 1960s and 1970s, groups of smallholder farmers from the foothills were granted underused land in the lowlands. All 'idle' land was subject to expropriation.
- *Nationalisation*. Under the 1974 'COHDEFOR Law', which formed the Honduran Corporation for Forestry Development COHDEFOR and established the Social Forestry System, ownership and management rights of trees and forests passed to the

government.[6] One of the effects of this law (intended to improve control and regulation of forest management and generate funds for the agrarian reform process) was to remove any incentive from landowners to protect trees (Suazo et al., 1997). This provision was reversed by the 1992 Law for the Modernisation and Development of the Agricultural Sector (LMDSA), which returned tree ownership rights to landowners.

- *Centralised controls.* Despite legal provisions for devolution of responsibilities to municipal authorities, the regulation of tree and forest use has remained highly centralised in AFE-COHDEFOR. In practice, enforcement by AFE-COHDEFOR has been patchy, and tree felling and sale activities are primarily controlled by police checkpoints on main roads. The new Forestry Law seeks to establish mechanisms for local decision-making and social control of forestry issues through Consultative Councils at community, municipal, departmental and national levels, however the effectiveness of these is yet to be proven in practice.

In general, forest legislation and policies have made little direct reference to the dry forest agro-ecosystem, focusing instead on the commercially important coniferous forests which dominate much of the interior of the country, and to a lesser extent the tropical broadleaf forests of the north coast. They fail to take into account the peculiarities of the dry forest typical of the study areas or the requirements of small farmers wishing to make piecemeal sales of trees arising from natural regeneration within agricultural areas. The new Forestry Law, approved in late 2007, does not significantly change this situation, although the opportunity still exists for such provisions to be made in the Regulations of the new law, which at the end of 2008 were in the process of being finalised.

How farmers use trees

The farmers interviewed in southern Honduras, in the course of this study, described a wide diversity of uses and benefits they obtain from trees, and listed the species which they most prefer for different uses. Most of the tree use described by the farm families interviewed (Box 4.1) is for subsistence purposes, principally in the form of firewood and timber for house construction. The difficulties faced by rural families in meeting their needs for tree products are often given as a justification for promoting tree-planting programmes. However, few of the farmers interviewed in this study actually reported having difficulty in obtaining sufficient tree products for subsistence.

Commerce in tree products is in most cases limited to the occasional sale of fruit, trade within the community in house posts, and the sale of occasional trees to meet cash needs.

Timber and firewood

The sale of timber and firewood is limited by problems of market access, and by the highly centralised and restrictive legal environment, which places significant time demands on farmers in obtaining permits, and does not differentiate adequately between the permit

6. COHDEFOR subsequently became AFE-COHDEFOR and, under the new Forestry Law, has been replaced by the ICF

Box 4.1 Tree uses listed by Honduran farmers, in order of importance
The following ranking is based on the number of sampled farmers who referred to the different uses.

1. Firewood
2. Timber for construction and sale
3. Fruit (for consumption)
4. Posts
5. Shade for houses and yards
6. Fruit (for sale)
7. Feed for cattle, pigs and chickens
8. Soil improvement
9. Natural medicines
10. Insecticides
11. Coffee shade
12. Shade for cattle
13. Protection of water sources
14. Environmental protection
15. Soap
16. Tools, carts
17. Animal hitching posts, chicken shelter
18. Leaves for washing dishes
19. Windbreaks
20. Setting milk for the production of curds and cheese
21. Ash for applying to banana plants

requirements for large scale commercial forest management operations and the occasional sale and transport of individual trees from agroecosystems.

In only one of the four communities studied in southern Honduras was a significant external trade in forest products found. This was the community of Los Coyotes, located close to the town of El Triunfo where there are many family-based workshops producing furniture from local timbers, especially *Cordia alliodora*. These workshops provide an important market for the trees that the farmers of Los Coyotes manage in their fields. These are typically sawn into planks at the stump and then transported manually or by mule to El Triunfo. As a result of promotion by the GTZ-funded COHAAT (later COHASA) project, farmers from Los Coyotes also sell firewood to El Triunfo and to the more important urban centre of Choluteca (Richards et al., 2000).

Table 4.2 shows the contribution that the sale of trees for timber can make to smallholder farm economies, contrasting small-scale farmers (<3.5 ha land) with relatively low tree densities (21 trees per ha), and larger-scale farmers (>3.5 ha land) with higher densities of trees (42 trees per ha). In the best case (large-scale farmers with many trees), the net benefit from trees is at least ten times greater than that from agricultural crops, with combined tree and agricultural income about 30% higher than that obtained by small-scale farmers with fewer trees. Agricultural incomes are reduced by less than 20%, implying that tree production need not have significant impacts on food crop production. The higher per hectare net benefit from tree production achieved by larger-scale farmers

Farmer in Agua Zarca, southern Honduras, with firewood collected from a cleared fallow. More than 70% of the farmers interviewed reported being able to obtain sufficient fuelwood; 74% could get enough timber and more than 90% could get sufficient posts. These products come mostly from naturally regenerated trees in fields and fallows.

is explained by their greater capacity to access markets for tree products (Richards et al., 2000).

The situation in Los Coyotes is by no means typical of southern Honduras. In the community of Agua Zarca, the net benefit from tree production only constituted between 9 and 13% of the combined net benefit. The difference between these situations is not due to the amount of tree material present, which was approximately equal in the two communities (Box 4.2); rather, the principal factor is the availability of easily accessible markets in the case of Los Coyotes compared to Agua Zarca where road access is difficult and there are no nearby market centres for timber.

Table 4.2 Annual average economic benefits ($/ha) from trees and crops in Los Coyotes

	Small-scale farmer (<3.5ha land and ca. 21 trees per ha) ($/ha)	**Large-scale farmer** (>3.5ha land and ca. 42 trees per ha) ($/ha)
Agricultural production		
Income	288	238
Costs (without family labour costs)	108	92
Gross agricultural return[a]/ha	180	146
Cost of family labour in agriculture	159	139
Net benefit[b]/ha	21	7
Tree production		
Income	31	177
Costs (without family labour costs)	3	49
Gross return of tree production[a]/ha	28	128
Cost of family labour in tree production	16	36
Net benefit[b]/ha	12	92

Source: Richards et al. (2000). **a.** Gross return = value of production minus costs of production, including the opportunity cost of capital, but without deducting the cost of family labour. **b.** Net benefit = value of production minus costs of production, including family labour

Non-timber forest products

A wide diversity of fruit is produced in many communities. Only communities with good access to markets (such as San Juan Arriba) commonly sell their fruit; otherwise it is mostly used for local consumption. Large quantities tend to be wasted because of pests and the lack of markets or local demand. In San Juan Arriba, market access is achieved through outside intermediaries (*coyotes*) who purchase fruit in the village and transport it to markets in nearby urban centres for resale.

Other than fruit, only two of the NTFPs found were of any economic importance to communities, and neither of these conferred widespread benefits to the local population.

- *Aceituno* (*Simarouba glauca*) soap is important in the case study community of Agua Zarca, as a substitute for purchased commercial soap. Seed is collected from female trees of this species, de-pulped and then shelled. The kernels are then boiled in water, which has previously been percolated through ash of certain preferred tree species. Soap manufacture is predominantly a women's activity; however it does little for their economic independence as it is primarily made for local consumption. Interviewees in other study communities in Honduras knew that soap could be made from *aceituno*, recognised the soap when it was shown to them, and said that older members of their communities used to make it but that the practice had now been discontinued. Extension agents report that the practice is principally concentrated in communities in the west of Valle Department, in the vicinity of Agua Zarca.
- The extraction of latex from *palo de hule* (*Castilla elastica*), a species that is confined to the wetter end of the zone and principally to riparian forest, is also geographically limited and carried out by only a few people. In the study community of San Juan Arriba, extraction is carried out by an outsider, who pays the owners of the trees a token sum for the privilege. The latex is extracted by means of incisions in the bark, which often reach high up the tree to the uppermost branches. The latex is used for the cottage-industry production of raincoats. The same latex was used by pre-Hispanic populations to make the balls used by Mayan people in the ball courts of temple sites such as Copán, in western Honduras.

Coffee farmer in San Juan Arriba, southern Honduras, wearing a coat waterproofed with the latex of *palo de hule* (*Castilla elastica*)

How farmers perceive trees

Farmers' perceptions of trees are influenced not only by the subsistence and commercial benefits they provide, but also by their impacts on crops and livestock. The farmers interviewed mentioned the negative effects of trees on annual crops much more frequently than any positive effects. The main negative effects they described were:

- Reduction of crop yields by tree shade;
- Competition for space (for example by the low-spreading *Curatella americana*);
- Damage to crops from raindrops falling from the leaves;
- Young crop plants being crushed by the leaves of large-leaved species such as *C. americana*;
- The yellowing of maize plants hit by exudate falling from *Gliricidia sepium*;

- Crop growth being affected by tree species considered to be 'hot'.[7]

The following positive effects were mentioned:

- Improvement of maize yields by falling leaves of *Albizia saman* and *A. caribaea*;
- Conservation of moisture in the *postrera* (second) sowing of maize (leading to the retention of even *Curatella americana*, otherwise considered as a harmful species);
- Provision of 'heat' by *Mimosa tenuiflora* to maize in cool periods.

Only in coffee plantations did farmers consider trees to have a net positive effect on production. In San Juan Arriba, the only one of the case-study communities in which coffee is grown in any quantity, trees are highly valued for shade as well as being a source of timber and fruit. In addition, a few producers who have received more education or training also recognise that leguminous species contribute to soil nutrient status.

With respect to livestock, the farmers interviewed made surprisingly little mention of the possible shade benefits of trees. On the contrary, it was widely noted that pasture development is adversely affected by tree shade. Tree foliage was only mentioned as being important as a source of animal fodder when cattle are introduced into fallow areas to graze or browse. Fruit were considered a more important source of fodder; cattle enjoy the fruit of *jícaro* (*Crescentia alata*), *carreto* (*Albizia saman*) and *guanacast*e (*Enterolobium cyclocarpum*).

Few farmers perceived trees in fields as having a hydrological role, although most farmers recognised the importance of protecting trees immediately around water sources. It appears that little work has been done in the region on clarifying the possible role of scattered trees and live stumps in fields in promoting rainfall infiltration and thereby buffering stream flows.

In the homegardens (*solar*) directly around the house, the principal benefit of trees was considered to be the provision of shade and coolness.

Species preferences

The farmers interviewed mentioned 67 species as being used for timber, 44 for firewood and 39 for posts (Table 4.3). However, a few species were listed much more frequently than most, including *laurel* (*Cordia alliodora*), *quebracho* (*Lysiloma* spp.) and *madreado* (*Gliricidia sepium*).

7. This 'hot' phenomenon is described for *C. alliodora*, *carbón negro* (*Mimosa tenuiflora*) and for the fallen leaves of mango (*Mangifera indica*) and *aceituno* (*Simarouba glauca*); some farmers relate it, at least in the case of *C.alliodora*, to nutrient competition and say that its severity increases with tree density.

Table 4.3 Species most reported as used for firewood, timber and fence posts in southern Honduras study communities

Species most reported as used for firewood	Species most reported as used for timber	Species most reported as used for fence posts
1. *Lysiloma* spp.	1. *Cordia alliodora*	1. *Gliricidia sepium*
2. *Cordia alliodora*	2. *Bombacopsis quinata*	2. *Cordia dentata*
3. *Albizia caribaea*	3. *Enterolobium cyclocarpum*	3. *Lysiloma* spp.
4. *Caesalpinia eriostachys*	4. *Albizia saman*	4. *Mimosa tenuiflora*
5. *Mimosa tenuiflora*	5. *Lysiloma* spp.	5. *Cordia alliodora*
6. *Gliricidia sepium*	6. *Swietenia humilis*	6. *Mimosa platycarpa*
7. *Acacia hindsii*	7. *Conocarpus/Rhizopora* spp.	7. *Bursera simaruba*
8. *Calycophyllum candidissimum*	8. *Calycophyllum candidissimum*	8. *Acosmium panamensis*
9. *Lonchocarpus* spp.	9. *Cedrela odorata*	
10. *Guazuma ulmifolia*	10. *Simarouba glauca*	

- There was a large amount of variation in species use between communities. Only nine species were reported as used in all four of the communities (*A. caribaea, A. saman, C. candidissimum, C. alliodora, C. dentata, G. sepium, Lysiloma* spp., *P. dulce and S. humilis*). These were also the species that were most frequently reported as being used in the four communities.
- Preferences are not simply a reflection of availability, however, as 16 species, although present in all of the communities, were only reported as used in one.
- Farmers are to a large extent able to satisfy their needs with their preferred species as shown by the high degree of overlap between those species reported as most used and those for which farmers express active preferences.
- Preferences tend to be very specific for different uses. *Aceituno* (*S. glauca*), for example, is preferred for making doors, *caoba* (*Swietenia humilis*) for beds, *laurel* (*C. alliodora*) for chairs, and *quebracho* (*Lysiloma* spp.) for house posts. These preferences are related to the species' characteristics; for example *C. alliodora* is valued for its strength, straightness and hardness, *madreado* (*G. sepium*) and *Lysiloma* spp. for their durability, and *S. glauca* for its resistance to splitting and to termite attack.

Access to tree products

The majority of farmers said that they did not have problems in satisfying their needs for firewood, timber and posts (see Table 4.4). Nearly a quarter of respondents did, however, report difficulty in obtaining firewood. Reasons given for limited availability of firewood included the distance between the agricultural plots (from which most firewood is obtained) and the house, limited labour availability for its collection, the conversion of agricultural plots to permanent pastures and the collection of firewood by outsiders. Shortages are to some extent seasonal, as dry firewood is difficult to obtain in the rainy season.

Table 4.4 Proportion (%) of informants in Honduras considering availability of different tree products to be sufficient (Suff.) and insufficient (Insuff.)

	Firewood		Timber		Posts	
Community	Suff.	Insuff.	Suff.	Insuff.	Suff.	Insuff.
San Juán Arriba	86	14	74	26	90	10
Agua Zarca	70	30	85	15	95	5
San José de las Conchas	87	13	90	10	90	10
Los Coyotes	71	29	95	5	100	0
Total	77	23	86	14	93	7

Farmers in lower wealth categories tended to experience greater problems of scarcity (see Table 4.5). However, the landless did not report problems obtaining posts or timber, as they have no land to fence in or build upon.

Table 4.5 Proportion (%) of informants in different wealth categories in Honduras considering availability of tree products to be sufficient (Suff.) or insufficient (Insuff.)

	Firewood		Timber		Posts	
Socioeconomic category	Suff.	Insuff.	Suff.	Insuff.	Suff.	Insuff.
A (landless)	66	33	100	0	100	0
B (with homegarden, but have to rent other land)	66	33	77	23	85	15
C (<7ha, do not rent land)	66	33	73	27	73	27
D (7-35ha)	92	8	92	8	100	0
E (>35ha)	100	0	100	0	100	0

The importance of species diversity

Rural families use a wide diversity of tree species. In the four communities studied, for example, 85 species were mentioned as used for firewood, timber and/or posts. In a focus group in the community of San Juan Arriba, participants listed 30 fruit tree species, which they actively cultivate in their homegardens.

The participants in San Juan Arriba showed, through a calendar of fruiting times, that it is beneficial to maintain a high diversity of trees in the homegarden in order to ensure that at least one species is in production in any given period of the year. In the case of trees used for firewood, timber or posts, however, species diversity is less important with most of the species reported to have more than one use. This implies that farmers do not necessarily need access to separate species for different products. The large number of species (28) reported as being used solely for firewood is apparently due to the opportunistic nature of firewood collection: although farmers express strong preferences for certain species, in practice they tend to collect what is easily accessible. Nevertheless the 85 species reported as used for firewood, timber or posts represent only 29% of the 291 species of trees and shrubs which the botanical survey found in the study communities and surrounding landscapes.

Table 4.6 Proportions of single-use and multiple-use species in the Honduran case study communities

	Number of species	% of used species (n=85)	% of recorded species (n=291)
Species used for firewood, timber and posts	22	25.9	7.6
Species with more than one use	40	47.1	13.7
Species with only one use	45	52.9	15.5
Only firewood	28	32.9	9.6
Only timber	9	10.6	3.1
Only posts	8	9.4	2.7

How farmers protect and manage trees

Farmers protect and manage trees very differently on different parts of the farm. In this section we discuss the implications of these forms of management and protection for the status of the tree resource in the fields, homegardens and woodlots.

Fields

In spite of farmers' concerns about the negative impacts of trees on crops, 82% of those interviewed reported protecting certain species in their fields. This protection consists of taking care, when clearing fallow areas or weeding, not to cut seedlings or stump regrowth of these species. In addition, farmers protect the trees (both small and fully developed individuals) from fire, by clearing firebreaks around their bases, and by spot-burning rather than broadcast burning to clear vegetation. In some cases they avoid the use of fire completely, even though this may require increased investment in labour, herbicide or pesticides.

An inventory carried out on 10 farms (see Box 4.2) found between 13 and 139 trees/ha protected in the fields. Farmers listed 46 different species as being actively protected in fields, but a few species are protected with much more frequency than others. These include *laurel* (*Cordia alliodora*), *caoba* (*Swietenia humilis*) and *quebracho* (*Lysiloma* spp.).

The trees which farmers protect in this way are the product of natural regeneration. It is rare for farmers to plant trees in their fields (except in fence lines, where they are generally planted as stakes), because of the risk of them being damaged by the cattle that are seasonally introduced into the fields to eat crop residues. Furthermore, the abundance of naturally regenerated

Box 4.2 On-farm tree material in Los Coyotes and Agua Zarca, southern Honduras

An inventory was carried out in 10 fields in two case study communities in southern Honduras. In each field, six sample plots, with an area of 100m² each, were inventoried. In all cases, the fields had already been cleared for cultivation, and had been sown with maize, *maicillo* or beans. None of the fields had been burnt.

Quantities of tree material found in farmers' fields (ranges of plots) in southern Honduras

	Agua Zarca (n=6)		Los Coyotes (n=4)	
	Average	Range	Average	Range
Trees/ha. (>2m height)	43	13–139	76	27–102
Stumps/ha. (<2m height)	5,636	2,917–7,550	6,496	3,983–8,500
Seedlings/ha. (<2m height)	4,628	1,567–10,167	1,546	1,367–1,650
Stumps+seedlings/ha.(<2m height)	10,286	6,567–17,717	8,042	5,633–10,067
Species/plot (100m² area)		8.8–13.3		13.0–16.0
Total species found	**89**			

trees and their products in many areas makes it unnecessary for farmers to invest in planting. Most of the tree planting that has been carried out has been the result of substantial support and promotion by NGOs or rural development projects, sometimes depending on the use of incentives to motivate farmers. In some cases this has involved farmers having to suspend the practice of introducing cattle into their fields until after the trees are established. This represents a cost to farmers in the form of reduced fodder production and reduced income from rental payment.

Farmers also implement silvicultural practices such as thinning and pruning in their fields. Although they may initially protect large numbers of small trees of certain species, they will only accept a limited number of mature trees as these cast shade on their crops. As the trees develop, farmers carry out progressive thinning in order to achieve the required balance between trees and crops, concentrating on eliminating poorly formed individuals. 60% of farmers who reported maintaining trees in fields also reported pruning trees. As with thinning, this practice is used to reduce competition between trees and crops for light, and to improve tree form.

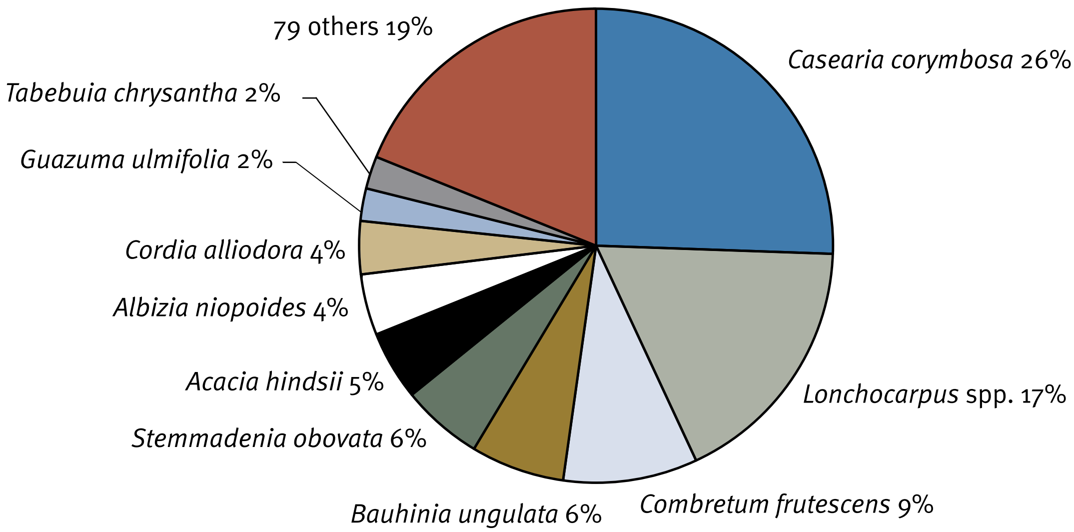
Abundant young natural regeneration in a field in Agua Zarca, southern Honduras. Between 5,633 and 11,583 individuals of tree species were found per hectare in farmers' fields. 99% of these were stumps and seedlings.

Table 4.7 Numbers of farmers reporting the active protection of different tree species in their fields in southern Honduras

Species	Farmers	% (n=79)
Laurel (*Cordia alliodora*)	30	38.0
Caoba (*Swietenia humilis*)	18	22.8
Quebracho (*Lysiloma* spp.)	16	20.2
Guanacaste (*Enterolobium cyclocarpum*)	8	10.1
Carreto (*Albizia saman*)	8	10.1
41 other species (of which 7 are exotics)	1–5 each	1.3–6.3

An important aspect of farmers' tree management practices is their relatively limited impact on those trees, which are not the object of active protection or management. In the 10 fields surveyed, an average of nearly 6,000 live stumps and 3,400 seedlings of tree and shrub species per hectare was recorded, in addition to the standing trees which were actively protected and managed by the farmers. Stumps and seedlings are profuse and of diverse species. A total of 89 species was found in the 6,000m^2 area sampled. A single species (*Casearia corymbosa*), however, made up more than 25% of all the individuals found, and 10 species between them accounted for more than 80% of all of the individuals (Fig. 4.2). The stumps persist in fields from one fallow period to the next, and the seedlings originate from the seed rain from neighbouring trees, or germinate from the latent soil seed bank once conditions are favourable.

Figure 4.2 Relative densities of species (seedlings, stumps and trees) in fields in two Honduran study communities



Farmer with a pruned laurel (*Cordia alliodora*) tree near Perspire, southern Honduras

The presence of so many stumps and seedlings, despite the fact that they compete with crops for space, results from farmers' limited capacities to eliminate them. Farmers are constrained by their limited labour resources, their limited economic capacity to purchase herbicides, and the steep topography which makes mechanisation difficult. Their only recourse is to resort to ineffective manual cutting by machete and, in many cases, burning.

Homegardens

In contrast to fields, the homegardens immediately around the house are typically dominated by planted trees. Here, there is little risk that they will be damaged by animals, except in those communities where homegardens are used as overnight corrals for cattle.

Trees planted in homegardens are normally allowed to develop unhindered as the shade they cast is welcome around the house. They are only felled or pruned in order to favour more valuable species, or to reduce the risk of branches falling on the house.

Fruit trees, often exotics, predominate. In some communities these are an important source of income and their proximity to the house facilitates protection and harvesting, while in others the main attraction is the ease of snacking. The homegarden is also typically used as the experimental area of the farm, where new, unfamiliar species acquired from other farmers or from extension agencies can be tried out before being planted elsewhere on the farm.

Woodlots

On-farm woodlots normally result when areas are abandoned (either permanently or temporarily). Most of the woodland areas in southern Honduras probably arose in this way. In some cases, the woodlot may be cleared again for agriculture after a number of years and another area of the farm set aside.

Woodlots are important for the production of firewood, timber and other products. The areas set aside in this way are typically the steepest and most inaccessible parts of the farm, least suited for agriculture. In some cases, however, the woodlot is deliberately left close to the house, as an easily accessible source of firewood. 29% of the farmers interviewed had an area of woodland, with an average size of 4.1ha, making up an average of 22.3% of their farms.

Conclusions: Key factors affecting how farmers use and conserve trees

The results presented above demonstrate clearly that conservation through use is a reality for many species in the agroecosystem of southern Honduras. A number of key factors can be identified as determining whether and how farmers carry out conservation through use.

Demand for tree products

Farmers' protection of trees in fields is motivated partly by their demand for tree products for subsistence uses, such as construction poles and fence posts. Where market access is good, farmers may also be motivated by the potential cash income from trees. Thus, the average number of trees found in fields in Los Coyotes (see Box 4.2), with its good access to furniture markets, was 34% higher than that in the relatively isolated community of Agua Zarca. As in Agua Zarca, opportunities for selling trees in much of the rest of southern Honduras are limited by an unfavourable legal environment, poor physical access to markets and the limited interest of the timber market for 'non-traditional' species (i.e. species other than *C. odorata*, *C. alliodora* and *S. humilis*).

Product scarcity

Farmers who protect trees in their fields do so because it is increasingly difficult to obtain them elsewhere in the landscape, and because they lack the capacity to purchase the desired products. This scarcity is to a large extent the result of the gradual reduction in the amount of fallow in the landscape, evident from time comparison of aerial photographs. Reduction in availability of valuable species is also due to over-exploitation in areas where access is poorly controlled.

It should be noted that protection as a response to scarcity is largely limited to those species which adapt easily to conditions in farmers' fields, such as *C. alliodora*. By contrast, *B. quinata* does not regenerate so easily in fields, forcing farmers in Los Coyotes, for example, to switch to more robust species, even if some of these (such as *G. ulmifolia*) have inferior product quality (see Table 4.1).

Use and tenure rights

Farmers only invest in protecting trees when they are sure that they will reap the eventual benefits. Although many farmers may lack formal title to their land, customary tenure generally provides sufficient security to motivate them to conserve trees for their future use. However, many farmers did mention worries about the government denying them harvest rights at some future date. This is a hangover of the legal situation from 1974 to 1992 when tree use rights were reserved to the State. Although this law has now been revoked, rural communities tend to be ill-informed about their legal rights, or to fear a subsequent reversal of the change.

Conversely, the Agrarian Reform Laws of the 1960s and 70s, although aimed at increasing farmers' access to land tenure, actually motivated farmers to deforest in some cases. Farmers in the community of San José de las Conchas, which was formed under the Agrarian Reform, described how they were obliged to clear trees and forests (despite their recognition of their future potential value) in order to demonstrate to the State that the land was being used productively and thereby avoid expropriation.

Many Honduran farmers, especially the land poor, cultivate on land rented from others. In this case the general rule is that rental confers no rights to extract tree products (except in some cases firewood, with the permission of the owner). Furthermore, rentals tend to be agreed on condition that potentially valuable trees are protected. This could be described as a form of conservation through use by proxy.

Regulation

Regulation is something of a double-edged sword. On the one hand, ineffective regulation, due to weaknesses in Government institutions and a failure to decentralise controls effectively to local level, coupled with an absence of effective community-based control, contributes to the degradation of tree populations in open access areas, such as stream sides and the properties of absentee landowners. Many of the local people interviewed reported that AFE-COHDEFOR had little or no presence at community level and considered that the application of the law tended unfairly to favour people with more resources. On the other hand, farmers wishing to protect trees on their own lands are in many cases discouraged from doing so by the difficulty of obtaining the permits necessary to transport the products to market. Farmers in one community explained how they prefer to invest in cattle than trees as a form of emergency savings, because a cow can be sold from one day to the next whereas it may take weeks to get permission to sell a tree.

5. Coastal Oaxaca: Community-based conservation

Coastal Oaxaca contrasts sharply with southern Honduras, having large areas of apparently intact MTDF. Another important difference is the existence of strong community-based controls on natural resource management in some parts of the area. In this chapter we show that conservation through use is very much in evidence in the Oaxaca study area, though it operates largely at the communal, rather than individual, level, and affects both forests as a whole and individual tree species. As in the case of southern Honduras, the principal factors which determine its application include the existence of demand and markets for the products of trees and forests; the level of scarcity of these products; and the effectiveness of regulation, in this case at the community level.

Historical background

In common with southern Honduras, coastal Oaxaca in Mexico had a sizeable pre-Hispanic population. The peoples who first arrived, between 7,000 and 9,000 years ago, were nomadic hunter-gatherers who depended heavily on the forest for the collection of subsistence products. These people gradually adopted a more sedentary lifestyle, forming small villages and beginning to modify their environment, for example through the establishment of agricultural plots on alluvial terraces. Increasing population growth and social organisation then led to the formation of urban centres and the expansion of colonisation, slash-and-burn agriculture and the gathering of forest products into new areas, including low-lying coastal plains. By the time the Spanish arrived, slash-and-burn agriculture was practised throughout the area, from the lowlands to the foothills of the Sierra Madre del Sur, while irrigated agriculture had become more important near to urban centres (Rodríguez Canto, 1995).

The arrival of the Spanish resulted in a major demographic collapse, estimated at 64% between 1550 and 1650 (Rodríguez Canto, 1995). This collapse was less severe than in Honduras and many of the cultural traits of the inhabitants survived to a greater degree, including communal forms of organisation and tenure. The colonial authorities in Oaxaca eventually took some measures to ensure the survival of indigenous communities, granting them land for habitation and cultivation (Velásquez Zepeda, 1998). Colonial production systems mirrored those in much of Central America: export crops were promoted on fertile coastal lands and cattle ranching expanded elsewhere.

During the post-Independence period (1810-80), the extraction of forest resources assumed an increased importance.

Dry forest in the hills of coastal Oaxaca, with flowering *Cordia elaeagnoides*

The species extracted included Brazil wood (*Haematoxylum brasiletto*), which was used as a source of dyes, mahogany (*Swietenia humilis*) and Spanish cedar (*Cedrela odorata*). The Mexican Revolution of 1910-20 led to communal tenure and resource management structures being enshrined in the 1917 Constitution. The agrarian reform, that belatedly followed the Revolution, established communities' tenure rights over enormous areas of the country, through the establishment and formalisation of communally managed *ejidos* and agrarian communities.

Despite initiatives during the 19th century to develop the productive potential of the coastal lowlands, the region remained relatively underdeveloped until recently, due in large degree to its isolation from the city of Oaxaca, the state capital, which itself suffered economic isolation from the rest of Mexico. This situation changed in the second half of the 20th century, when trunk roads and airports improved communications with the rest of the country. The second half of the 20th century also saw important influxes of population into the area. It was in this period that several of the study communities were formed, by immigrants from deprived areas in the interior valleys of Oaxaca and indigenous areas of the Sierra Madre del Sur.

Trends in tree and forest resources

Although the forests in coastal Oaxaca have not suffered the same wholesale clearance for agriculture as has occurred in southern Honduras, the situation is far from stable. Rates of change are even harder to estimate than in Honduras as the aerial photographs available do not permit comparison over a period of several decades. Trends must therefore be inferred from the explanations offered by the farmers interviewed in the four study communities.

El Sanjón is the community in which the vegetation has undergone most change over the last 50 years. When the first of the present inhabitants arrived from nearby San Pedro Tututepec in the 1950s, taking over the lands from their earlier large landowners (*latifundistas*), the lowlands of El Sanjón were largely forested and used only for extensive grazing, with occasional agricultural clearings. Since then, the forests have been converted almost entirely to lemon plantations, sown pastures and permanent cropping areas.

Lemon trees, El Sanjón, Oaxaca

The community of Petatengo is also the product of largely local migration; most of the first arrivals were farmers from the nearby community of Santa María Xadani who previously used the area for grazing their cattle and subsequently settled there. The current inhabitants describe the area as having been entirely forested ('*puro monte*') when they arrived. Today, half of the community's land is an open grazing area, with much forest cover remaining (albeit affected by grazing), and the rest is used for agriculture with many individually-fenced plots.

Most of the present day inhabitants of El Limón migrated there from indigenous communities in the Sierra Madre del Sur over the last 50 years. There had previously been another community on the same site, hence much of the area may earlier have been cleared for agriculture and then allowed to return to fallow once the community was abandoned.

In La Jabalina, the areas currently used for agriculture were first cleared in the 1960s and then, with some exceptions, allowed to return to fallow. They were then cleared and occupied again when the present inhabitants of the community were displaced in the 1980s from their homes on the coast by the establishment of the Bahías de Huatulco tourism complex. More land was cleared by people who moved from further inland to settle along the length of the coast road when it was constructed in the 1970s. In some cases this allowed their original areas to revert to forest.

In all of the communities, farmers mentioned that certain species had become scarcer in recent years (see Table 5.1). In El Sanjón, this scarcity was attributed principally to the wholesale clearance of lowland forests for agriculture. In the other communities, the principal cause was considered to be over-exploitation of individual trees for timber and other extractive uses (e.g. *A. adstringens* (*cuachalalá* bark) and *C. odorata* (Spanish cedar) in El Limón).

Table 5.1 Species reported to have declined in abundance in the Oaxaca case study communities

El Sanjón	La Jabalina	El Limón	Petatengo
Lowlands: *Acacia farnesiana* *Astroneum* spp. *Calycophyllum candidissimum* *Enterolobium cyclocarpum* *Hymenea courbaril* *Pithecellobium dulce* *Swietenia humilis*	*Cedrela odorata* *Cordia elaeagnoides* *Guaiacum coulterii* *Swietenia humilis*	*Amphyteringium adstringens* *Casearia tomentosa* *Cedrela odorata* *Cordia elaeagnoides* *Hintonia latiflora* *Swietenia humilis*	*Andira inermis* *Tabebuia rosea* *Poeppigia procera*
Higher lands: *Comocladia engleriana*			

Smallholder agriculture today

Present day smallholder agriculture in coastal Oaxaca is similar in some respects to that practised in southern Honduras, described in the previous chapter. The principal annual crops produced in the four study communities are maize and beans; others include squash, water melon, rock melon, peanuts, chilli, tomato, sesame and Jamaica sorrel (*Hibiscus sabdariffa* L.). The importance of these minor crops varies greatly between communities.

An important contrast with southern Honduras is that significant numbers of farmers in coastal Oaxaca practise some mechanised agriculture and/or irrigate some of their crops. Mechanised agriculture in particular has implications for the management of native vegetation as it leads to the removal of stumps and the permanent cultivation of plots, rather than cyclical fallowing and cultivation. However, more than 70% of interviewees did report fallowing their land. Another important difference between the two study areas is that, whereas cattle in southern Honduras are largely enclosed, much of the livestock in the Oaxaca study communities (particularly goats and sheep) grazes freely in open access areas.

The frequency of these different practices varies widely between communities (Table 5.2). El Sanjón stands out as having markedly different production systems to the other three communities. The flat coastal lands which make up a large proportion of its area have been almost completely cleared and destumped and are now dominated by plantations of lemons, which are sold to nearby markets and provide an important source of income.

Table 5.2 Frequency of different agricultural practices in case study communities in coastal Oaxaca

Case study community	% of farmers practising mechanised agriculture	% of farmers irrigating their land	% of farmers who fallow their land	Average length of fallow (years)	% of farmers with livestock		
					Cattle	*Goats*	*Sheep*
El Sanjón	81	68	50	3.0	25	15	0
Petatengo	52	0	50	3.5	30	30	20
El Limón	0	50	94	11.5	0	15	15
La Jabalina	10	22	93	3.4	40	5	0

Institutional environment

In Mexico, the institutional framework for conservation initiatives is a complex one, characterised by many actors, both government and non-government, at multiple levels. With as much as 80% of Mexico's forest in the hands of *ejidos* and indigenous communities (Bray et al., 2005), communal action is an important feature of local level resource management.

Government

Three levels of government are provided for in the Constitution of the Mexican Republic: federal, state and municipal. At the federal level, the two key ministries of relevance to conservation and rural development, respectively, are the Secretariat of Environment and Natural Resources (SEMARNAT) and the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA), both of which have delegations at state level. SEMARNAT includes the National Commission for Protected Natural Areas (CONANP), the National Forestry Commission (CONAFOR), the National Water Commission and the National Ecology Institute (INE). These secretariats and their dependencies are responsible for policy formulation, regulation and the implementation of projects and programmes.[8] The Minister of SEMARNAT is also Technical Secretary of the multi-sector National Commission for Biodiversity (CONABIO).

The Federal Government has implemented a number of important programmes related to agricultural productivity and agrarian reform; including PROCAMPO, aimed at promoting and stabilising agricultural production through the provision of incentives; PROCEDE, aimed at formalising communities' tenure rights; and the National Micro-Watersheds Plan, implemented by SAGARPA through the Shared Risk Trust Fund FIRCO.

Initiatives sponsored by the Federal Government have had something of a chequered history in the coast region. Most notable has been the expropriation of large areas of communal land in the municipality of Santa María Huatulco by the National Tourism Fund FONATUR. As described in Box 5.2, this exacerbated mistrust among local communities in relation to the establishment of a Federal National Park in the same municipality.

There is interest among state governments to achieve increased decentralisation of responsibilities, including the management of natural resources. This has led them to promote their own conservation initiatives as an alternative to those promoted by federal entities such as SEMARNAT. The Oaxaca State Ecological Institute, for example, parallels the federal INE, and there are moves to establish a system of protected areas at state level.

Within municipal governments there exist *regidores ecológicos* charged with environmental issues. These tend to be largely political posts, however, and in general the role of municipalities in relation to environmental issues is frequently limited to urban areas. They do, however, have an important role as the focal point for government funded initiatives in both conservation and rural development, such as the National Micro-Watershed Plan coordinated through SAGARPA.

NGOs

There is a great diversity of NGOs in Oaxaca, working at varying scales to promote conservation and rural development in the coastal region. Their main focal point is the city of Oaxaca itself, although there are a number based in the coast region.

Several initiatives have sought to promote dialogue and coordination between the many NGOs. These include the Oaxacan Commission for Ecological Defence (CODE) and, most notably, the Oaxaca Programme of the WWF, the latter having had an important role in the conception and early development of several conservation orientated organisations (Gordon, 2006). These initiatives have contributed significantly to communication between NGOs, although notable differences of approach remain. Some conservation and rural development NGOs focus strongly on grassroots participatory approaches, in contrast with the more centralised approaches of some government institutions.

---

8. The conversion of SEMARNAP to SEMARNAT under the Government of President Fox was accompanied by a considerable degree of decentralisation, and a reduction in the relative role of the institution in the implementation of projects and programmes.

The WWF has also functioned as an important conduit of funding from sources such as the European Union and the UK National Lottery. In general, NGO activity in Oaxaca is heavily dependent on external funding, both international (e.g. from the Ford Foundation and MacArthur Foundation) and national, as in the case of the Mexican Fund for Nature Conservation (FMCN). The reduction of SEMARNAT's implementation role has also opened further opportunities for these NGOs to implement government-funded projects.

Community structures for management and conservation

In much of the coastal region, there is a high level of organisation at community level. The four case-study communities (see Chapter 3) illustrate the different organisational structures provided for in the 1917 Mexican Constitution, and demonstrate their functioning and varying degrees of effectiveness under a range of conditions.

In all of the study communities, two parallel structures exist: the municipal government and the agrarian authorities. The physical boundaries of the jurisdictions of these two entities do not generally coincide. In some cases, the agrarian unit may be approximately equivalent in scale to a municipality but in others a municipality may overlap with a number of agrarian units.

Agrarian authorities are principally concerned with agrarian and natural resource issues. The highest decision-making body to which agrarian authorities respond is the assembly of the members of the community. Decisions are taken by vote, a simple majority being necessary to approve or reject a motion.

In *ejidos* (such as the El Limón study community), only the *ejidatarios* (formal members of the *ejido*, all of whom are men) have the right to a voice in the assembly; *avecindados* (people allowed to reside in the community without formal tenure rights) are excluded. In the Petatengo study community, while all men over the age of 18 have a vote, women can only vote if they are single or widowed.

Policy and legislative environment

The communal forms of management that survived the Spanish conquest were undermined by the Liberal reforms of the late 19th century. However, the Mexican Revolution and the ensuing 1917 Constitution provided the basis for the agrarian reform, the communal territorial units (agrarian communities and *ejidos*) and the administrative structures on which today's communal organisation, tenure and management are based. In 1992, neo-liberal desires to achieve increased efficiency in the rural sector by promoting individual tenure and land management patterns led to the modification of the Constitution in 1992 and a new Agrarian Law. This, for the first time, allowed *ejidatarios* to sell their land, and saw the implementation of incentive schemes such as PROCAMPO, which require beneficiaries to demonstrate continuous occupancy of fixed plots of land.

In practice, such moves at legislative and policy level to promote private tenure appear to have had relatively limited implications for communally-based regulation and management. For the time-being, few *ejidatarios* have taken advantage of the amendment and sold their land. A more significant influence on both *ejidos* and agrarian communities appears to be the informal privatisation of tenure through the fencing off of communal lands for individual use.

At the same time, the last two decades have seen an increasing legal recognition of communities' rights to manage their natural resources in a decentralised and autonomous manner. Most notable have been the two Forest Laws of 1986 and 1997, the LGEEPA (*Ley General de Equilibrio Ecológico y Protección del Ambiente*) of 1996 and, at the international level, Treaty 169 of the International Labour Organisation regarding the rights of indigenous communities.

How farmers use trees and forests

The range of different uses and benefits obtained from trees and forests listed by the informants in coastal Oaxaca (Table 5.3) is as diverse as that reported for southern Honduras (Box 4.1). A number of these products are commercialised, for example, baskets made from *carrizo* (a type of bamboo), the bark of *cuachalalá* (*Amphyteringium adstringens*), furniture made from *ocotillo* or *grisinia* (*Cordia elaeagnoides*), and firewood from *palo de arco* (*Apoplanesia paniculata*).

Of the uses and benefits mentioned in Table 5.3, the majority are obtained from individual trees, either within the forest or in the agricultural landscape. Only four of those mentioned depend on the existence of the vegetation in general (hunting, soil fertility restoration, ecotourism and iguana raising). In addition to benefits, farmers also mentioned a number of disadvantages and problems caused by trees (Table 5.4).

A farmer in El Limón, Oaxaca, holding the bark of *cuachalalá* (*Amphyteringium adstringens*) sold for its medicinal properties

Species preferences

Farmers mentioned 56 different species used for firewood, 97 for timber and 31 for medicines, out of a total of 448 tree and shrub species recorded by the botanical survey. Table 5.5 lists the most commonly reported firewood and timber species. As is the case in Honduras, the species used vary widely between communities: 79% of firewood species and 75% of timber species were only reported as being used for these purposes in one community. Only three out of 97 timber species (*Calycophyllum candidissimum, Enterolobium cyclocarpum* and *Swietenia humilis*) were used in all four communities. Only in El Sanjón, where extensive plantations of lemons and coconuts exist, were lemons (*Citrus* spp.) and coconuts (*Cocos nucifera*) reported as being used for either timber or firewood.

Table 5.3 Examples of uses and benefits obtained from trees in coastal Oaxaca

Use	Examples of species used
Timber	Various species, see Table 5.5 for detail
Firewood	Various species, see Table 5.5 for detail
Posts	Various species
Tools	*Tabebuia rosea*
Furniture	*Cordia elaeagnoides*
Fruit	*Mangifera indica, Byrsonima crassifolia, Spondias mombin, Leucaena esculenta, Tamarindus indica*
Forage	*Cordia dentata, Guazuma ulmifolia*
Hunting	The forest as a whole
Medicine	Various species
Soap	*Thouinidium decandrum, Coccoloba* spp.
Baskets	*Bambusa* spp.
Brooms	*Xoyamiche* palm
Soil fertility restoration	Fallow vegetation in general
Demarcation of boundaries	*Mangifera indica*
Roosting places for chickens	*Mimosa tenuiflora, Gliricidia sepium*
Poles for harvesting lemons	*Guazuma ulmifolia*
Roofing	Palms, coconuts, straw
Ecotourism	The forest as a whole
Washboards	*Cordia dentata*
Dyes	*Haematoxylon brasiletto*
Medicine for animals	*Cochlospermum vitifolium*
Kindling	*Haematoxylon brasiletto*
Mills for grinding grain	*Hymenea courbaril*
Iguana raising	Small woodlands

Table 5.4 Disadvantages and problems of trees mentioned by farmers in coastal Oaxaca

Problem	Situation or Species
Agriculture	
Interference with agricultural machinery	In lemon orchards and other cultivated lands e.g. *Enterolobium cyclocarpum*
Thorns make manual work difficult	In agricultural plots e.g. *Acacia collinsii*
Shade (competition for light with crops)	Agricultural plots and lemon orchards e.g. *Pithecellobium dulce*
Shade (competition for light with pasture)	In pastures
Yellowing of crops	*Gliricidia sepium*
In homegardens	
Shade (competition for light with other trees)	e.g. *Enterolobium cyclocarpum, Muntingia calabura*
Threat of falling on the house	e.g. *Gliricidia sepium, Enterolobium cyclocarpum*
Excessive production of flowers and leaves	e.g. *Tabebuia rosea, Ipomoea wolcottiana*
Health	
Toxic or irritating properties	e.g. *Ficus* spp., *Comocladia engleriana*

Table 5.5 Species most reported as used for firewood and timber in Oaxaca case study communities

Firewood	Timber
1. *Hesperalbizia occidentalis* 2. *Apolplanesia paniculata* 2. *Gliricidia sepium* 4. *Citrus* spp. 5. *Guazuma ulmifolia* 6. *Acacia collinsii/hindsii* 6. *Cordia alliodora* 8. *Acacia cochliacantha* 9. *Acacia farnesiana* 10. *Cocos nucifera*	1. *Cordia elaeagnoides* 2.*Comocladia engleriana* 2.*Hesperalbizia occidentalis* 4.*Cordia alliodora* 5. *Enterolobium cyclocarpum* 6. *Gliricidia sepium* 7. *Apoplanesia paniculata* 7. *Cocos nucifera* 9. *Calycophyllum candidissimum* 10. *Tabebuia rosea*

Sources of tree products

In contrast with southern Honduras, most farm families in the Oaxaca study area obtain their tree products from communal land that can be freely accessed by all community members, rather than from their own plots (Table 5.6).

Table 5.6 Sources of firewood and timber reported by farmers in Oaxaca case study communities

Source	% of farmers (n=80)	
	Firewood	Timber
Communal land	62.5	53.8
Homegardens	30.0	3.8
Agricultural plots	18.8	16.3
Pastures	0	1.3
Others' land	5	3.8
Purchase	3.8	10.0

El Sanjón, with its extensive commercial plantations, differs markedly from the other communities studied, with respect to where its inhabitants obtain tree products. Only three interviewees in El Sanjón (15%) reported obtaining timber from communal lands compared to an average of 67% of informants in the other three communities, while six people in El Sanjón reported purchasing timber compared to only two in Petatengo and none in either of the other two communities.

Protection and management of trees and forests

Tree planting

All of the farmers interviewed said that they had planted trees at some time or other. However, this activity is concentrated in farmers' homegardens (*solares*).[9] 99% of farmers reported having planted trees in their home gardens, whereas only 22% had done so in their cropping areas. A total of 95 different species were reported as having been planted in homegardens, compared to only 17 in cropping areas. The top 10 species planted in homegardens are all fruit trees, of which only three are native (*Spondias mombin, Leucaena esculenta* and *Byrsonima crassifolia*). Only 22% of the species planted in homegardens were reported as being used for timber and 13% for firewood. In cropping areas, 9 of the 17 planted species were reported as being used for timber (principally *Gliricidia sepium*, *Swietenia humilis* and *Tabebuia rosea*).

9. As in southern Honduras, *solares* in the Oaxaca study communities are highly variable in nature and tend to be defined principally by their proximity to the house.

In Petatengo, community members have been encouraged by a local NGO to carry out enrichment planting in communal forests (see Box 5.1). This reforestation is intended to increase the commercial value of the forest, both in terms of direct products for the community and of hydrological services for downstream neighbours, thus increasing the community's incentive to conserve it.

Tree planting commonly involves movement of tree material between communities, and between different parts of the same community, in the form of seed, transplanted natural regeneration, or live posts or branches for planting as stakes. In El Sanjón, which consists of an upper area of staple grain production with some secondary forest and fallows, and a lower area with houses and commercial lemon plantations, the downward movement of tree material is dominated by timber species collected in the upper forests and fallows, and the upward movement by fruit trees (mostly exotics), medicinal plants and ornamentals collected in lowland homegardens. Inter-community movement of germplasm is generally based around family relations, and is also dominated by fruit trees, ornamentals and medicinal plants.

Box 5.1 Commercial extraction and reforestation in communal lands in Petatengo

The NGO, *Centro de Soporte Ecológico* (CSE), has promoted the marketing of timber and other tree products from communal areas of Santa María Petatengo, with the aim of generating income for the community and thereby increase local peoples' motivation to conserve their forest resources. At the same time, CSE has also promoted reforestation to balance the extraction and enrich the resource. One of the principal motivations for the project has been the perceived threat to the future water supplies of the nearby tourist centre of Bahías de Huatulco, posed by deforestation inland (Barkin and Paillés, 1998). It is hoped that the community will be paid for protecting the forest's hydrological services.

The processing and marketing activities focus on the utilisation of currently undervalued material (because of its small diameter or species, e.g. *Bursera* spp.), for the production of turnery, cellulose for hand-made paper, and handicrafts. The aim is that "technological innovations associated with existing market opportunities will allow wood products rather than raw trees to be marketed, with more employment and value accruing to the communities;....these communities have suffered from unfavourable conditions for their products for decades....as the market works to exacerbate the discrimination imposed by society against indigenous groups and peasants, placing a low value on their labour and the products of their work" (Barkin and Paillés, 1998).

CSE has held more than 70 consultation and planning meetings with the community. Concerns about individuals gaining commercial benefit from naturally-regenerated trees in communal lands have led to the decision that the whole area will be managed communally and benefits will be distributed equally among the population as a whole.

The reforestation is principally in the form of enrichment planting underneath the canopy of existing forest in the communal grazing area (*agostadero*), using plants of native species raised in two communal nurseries from locally-collected seed. By the end of 1999 around 600,000 trees had been planted (Paillés, C., pers. comm., 2000). The programme encountered some opposition from larger ranchers, concerned that reforestation activities in the *agostadero* would lead to restrictions on grazing. Other community members were fearful for the community's tenure over the reforested lands.

Protection of trees by individuals

Active protection of trees is concentrated in the homegardens, where it focuses on planted, rather than naturally regenerated trees. This protection consists principally of fencing in order to avoid trees being browsed by animals. The way this is arranged varies widely between communities. In El Sanjón, for example, a single fence may enclose several houses and home gardens, while, in Petatengo, valued plants are established within a small fenced area in each homegarden.

In contrast to southern Honduras, trees in cropping areas rarely receive active protection. In only one of the four communities, Petatengo, was this reported, largely in response to motivation by an NGO. One of the participating farmers in this community described how "previously vegetation was uniformly cleared, but now a number of farmers leave trees for timber and the house [firewood]; they do not interfere with crops as they grow straight".

Trees are also protected through unwritten rules governing the relations between individuals. These apply principally to areas where communally owned lands have been enclosed for individual use. In El Limón, for example, it is necessary to ask the permission of an *ejidatario* (community member) and make a small payment in order to be able to fell a tree within his enclosure.

Silvicultural management

The principal forms of silvicultural management are irrigation and pruning branches. Both practices, but particularly irrigation, are more frequent in homegardens than in cropping areas. Some farmers mentioned the availability of water for irrigation as a prerequisite for planting trees. The main objective of pruning is to reduce some of the negative effects of trees, such as competition with other trees, the production of excessive quantities of fallen leaves and the risk of branches falling on the house. In the cropping areas, negative effects are normally overcome by simply eliminating the trees in question.

Community-based protection

In all of the study communities, formal controls exist (at least in theory) at community level on the felling of trees for timber and the clearance of forest areas. In El Limón, for example, the community assembly introduced a prohibition on the felling of Spanish cedar (*Cedrela odorata*) and restrictions on the extraction of the bark of *cuachalalá* (*Amphyteringium adstringens*), because of concerns over their local over-exploitation.[10] However, in practice, each community member is largely free to fell trees within their own plots and will only be fined if they fell trees outside of the communal territory, in order to avoid conflicts with neighbouring communities.

In Petatengo, the communal assembly has restricted the issue of permits for felling *guanacastle* (*Enterolobium cyclocarpum*) or *macuil* (*Tabebuia rosea*). In contrast to El Limón, the controls in Petatengo are generally well respected.

10. Across the study area as a whole, *A. adstringens* is a common and freely regenerating species, whose conservation status gives no cause for concern from the global perspective.

Only in El Limón were community controls over the collection of firewood mentioned. These norms specify where it can be collected (not too close to the urban centre) and prohibit the cutting of live trees for firewood. In Petatengo, firewood collection is regulated by agreements between individuals: it may not be removed from enclosures without the permission of their 'owners'.

Among the most effective communally-based controls encountered were those in Santa María Huatulco. In order to protect areas of forest for ecotourism, the agrarian authority (*comisariado de bienes comunales*) introduced a restriction on the felling of high forest ('*monte grueso*' or '*montaña*') for the establishment of agricultural plots. Particularly significant is the establishment of communally-managed protected areas (see Box 5.2).

The use of fire to prepare agricultural plots is also subject to community based controls in order to reduce the risk of it spreading to forest areas. In La Jabalina, the *comisariado* of Santa María Huatulco has imposed a complete ban on burning. In Petatengo, the assembly decided to permit burning only in the cooler afternoons and, if a fire escapes, the person responsible is fined in proportion to the area burnt and the damage caused.

Box 5.2 Communal and Federal Reserves in Santa María Huatulco

For a number of years federal authorities have planned to declare a federal reserve (national park) on some of the better conserved areas of Santa María Huatulco municipality, and of the area expropriated by the National Tourism Fund FONATUR for the Bahías de Huatulco hotel complex in the 1980s. This proposal was strongly opposed by local communities, which, through their agrarian authority, established 'Communal Forestry and Fauna Reserves' as an alternative. When the Huatulco National Park was established in 1999, it covered approximately 6,000ha of the onshore part of the expropriated area in addition to protected coastal waters.

The Communal Reserves today cover some 15-20,000ha, equivalent to around 35% of the communal lands of Santa María Huatulco. In these areas, the use and management of natural resources is regulated, and the clearance of forest and commercial hunting are prohibited. A number of entry points are marked by signs and are chained or gated.

A Consultative Committee has been established by the agrarian authority, the municipal authorities and with the initial support of the local NGO GAIA in Santa María Huatulco, which advises on decisions relating to the community's natural resources. A heritage fund has been established, which includes the trust fund established as compensation for the land expropriation of the 1980s. It is intended to use this for development and conservation activities.

The interest of the local communities in establishing the reserves is motivated in part by the potential for revenue generation from ecotourism, given the proximity of the Bahías de Huatulco hotel complex. A number of ecotourism operators (mostly outsiders) currently run day tours to the reserve from the hotel complex. Communally managed protected areas in Mexico are now eligible for federal support through CONANP, just as National Parks are. The long-term effect of this on communal reserves in Santa María Huatulco has yet to be clarified. However, at present, the benefits are mostly concentrated in the hands of outsiders or a few wealthier families. It has been proposed that fees be introduced for outside researchers who wish to work in the area.

Attempts to control extraction of non-timber forest products (NTFPs) have been made in El Limón, where the medicinal *cuachalalá* bark (*Amphiteryngium adstringens*) is harvested for sale in towns such as Tehuantepec and Juchitán. The existence of good markets leads to high levels of extraction. Instead of removing small quantities of bark, as happens in communities where it is only gathered for subsistence use, whole trees are typically felled in order to obtain sufficient quantities for sale. The assembly has recommended modifying extraction practices in order to prevent over-exploitation. However, the recommendation appears to have had little effect because of the economic importance of the sale of *cuachalalá* bark for local people and the fact that in this community the authorities have little say over members' activities in their individual plots. In La Jabalina, the agrarian authority has prohibited hunting for commercial purposes, and has established closed seasons for the hunting of certain animals such as iguanas and deer.

Conclusions: Key factors affecting the conservation and use of trees and forests

In contrast to southern Honduras, the examples of conservation through use found in Oaxaca largely operate at the community, rather than individual, level. There was relatively little evidence of individual farmers conserving individual trees because of their perceived utility, with the significant exception of trees being planted in homegardens as a source of fruit (and most of these are exotics). Community-based CTU was evident at both species and ecosystem levels. Examples of the former include the decrees by the communal authorities in El Limón restricting the extraction of bark from *A. adstringens*. The most notable example of the latter is the establishment of communally owned and managed reserves in Santa María Huatulco (which includes La Jabalina community). Three factors appear to be key in determining whether and how farmers carry out conservation through use.

Demand and markets

The continuing conservation of communal forests in Santa María Huatulco (Box 5.2) is partly motivated by perceptions of a demand for ecotourism and hydrological services, because of the presence in the nearby Bahías de Huatulco hotel complex of a consumer population with significant capacity to pay for these services. In practice, the functioning of the CTU mechanism is currently limited by poorly-operating markets; much of the ecotourism revenue goes to external operators because mechanisms to compensate community members for their watershed protection activities are not yet functional.

In the case of El Limón, the existence of markets for tree products (such as the bark of *A. adstringens*) is leading instead to resource degradation. *A. adstringens* was reported as occurring, and being valued, in all of the other study communities; however it was only in El Limón, with its ready access to markets for medicinal products in the Isthmus of Tehuantepec, that problems were reported with the sustainability of its use.

In El Sanjón, by contrast, it is a lack of demand for the products of native trees that is partly responsible for local people's limited interest in protecting tree populations. The relatively ready access members of this community have to cash income, through the sale of lemons or off-farm employment, enables them to purchase building materials rather than depend on obtaining them from naturally regenerated trees. Their dependence on native trees is further reduced by the ability of the lemon and coconut plantations, which dominate much of the landscape, to provide the required tree products (firewood and building materials respectively).

The significance of demand for tree products in influencing the occurrence of CTU must also be seen in comparison with other sources of income generation. In El Sanjón, for example, lemon production on the easily cultivable flat lands offers an attractive alternative to the sale of the products of naturally-regenerated trees.

Product scarcity

The contrast between southern Honduras and much of the Oaxaca study area is striking, in terms of the relatively large amount of forest and fallow present in the latter. The ready availability of tree products from communal lands in the Oaxaca study area, in most cases removes the motivation for individual farmers to protect trees within their fields, where they are considered to interfere with crop development.

Nevertheless, actual or potential scarcity is the justification for the restrictions imposed by the communal authorities in El Limón and Petatengo on the extraction of *A. adstringens*, *C. odorata*, *E. cyclocarpum* and *T. rosea*. This scarcity is largely due to the existence of high levels of demand for the products of these species.

Community regulation

In situations where individuals' perceptions of resource values are not sufficient to protect values of importance to the community as a whole, it may be necessary for the community to regulate the actions of individuals in order to bring about conservation. The relatively effective protection of trees and forests in La Jabalina and Petatengo, in response to community-level perceptions of their use value, is largely a function of the well-developed and respected community-based regulation that exists there. In Santa María Huatulco this has permitted the establishment of large communal reserves; in Petatengo, in addition to controls on the harvesting of particular tree species, it has enabled the definition and enforcement of a system of land-use zoning aimed at minimising conflicts between livestock and agriculture.

This contrasts with the situations in El Limón and El Sanjón, in both of which tree and forest resources have suffered significant degradation (although in El Limón significant areas of forest still remain). In El Limón, the effectiveness of controls on the extraction of *A. adstringens* bark has been undermined by the attractiveness in the short term of exploiting the resource to the maximum. On the flat lands of El Sanjón, the clearance of trees is subject to little regulation, largely because of their limited use value relative to alternative land uses.

Another factor, which appears to influence the effectiveness of regulation, is land tenure. There is a progressive tendency in much of the study area towards the claim of exclusive use rights by individuals over areas of community land. The proportions of community lands affected by this process vary widely between communities. This *de facto* 'privatisation' of land tends to limit the effectiveness and relevance of community-based regulatory structures, whose main role, under the provisions of the agrarian legislation, is the administration and defence of community resources. An extreme example of this, among the study communities, is the situation in El Sanjón, where almost all land is individually managed and community-level controls over individuals' management of their land are limited. Similarly, the designated community members (*ejidatarios*) in El Limón are largely left to their own devices within their individual plots. In La Jabalina and Petatengo, by contrast, large areas of common land remain and community controls remain strong. Conversely, the lack of individual tenure was one of the reasons farmers gave for not planting trees.

6. Global conservation priorities in the MTDF

In this chapter we draw on our botanical survey results to respond to our second research question relating to which MTDF tree species and sites should be the prime focus of conservation action. While many tree and shrub species of global conservation concern were found in coastal Oaxaca, none were found in the Honduran sample sites. In coastal Oaxaca, forest fallows were found to be an important location for conservation priority species, suggesting that current land-use practices have much to offer conservation initiatives.[11]

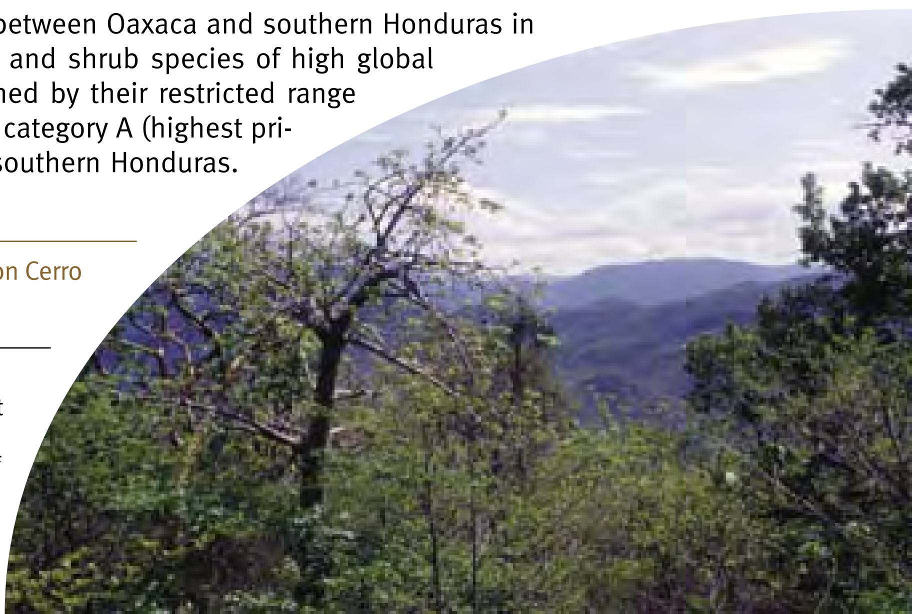
Species of conservation concern

In the course of the botanical fieldwork in southern Honduras and Oaxaca, we found and identified 594 species including many exotics, some that would not normally be considered trees or shrubs and species from transition forests around MTDF. A full list of these species is given in Appendix 4. As outlined in Chapter 3, the species were grouped into four conservation priority categories. Across the two study sites, a total of 78 species are considered to be of conservation concern (Categories A, B or C in Table 3.3) because of their restricted ranges.[12] Of these, 17 are endemic to the Pacific dry forest zone of Honduras or Oaxaca and are therefore classified as Category A (highest conservation concern).

In addition, three species were found that were not classified as category A, B or C, but are listed by IUCN as 'vulnerable' (*Bombacopsis quinata* and *Swietenia humilis*) or 'endangered' (*Guaiacum sanctum*). Two of these (*G. sanctum* and *S. humilis*), as well as *S. macrophylla*, are also listed under CITES II for international trade (but see Box 6.1). This highlights the different outcomes (in terms of conservation actions) that can arise through use of different assessment methods. The rapid botanical survey presented here, in which threat status of individual species was based on their global ranges, is relatively fine-grained and provides a useful tool to identify truly threatened species.

Location of the priority species

There is a striking difference between Oaxaca and southern Honduras in terms of the numbers of tree and shrub species of high global conservation priority, as defined by their restricted range (Fig. 6.1). This study found no category A (highest priority rating) species at all in southern Honduras.



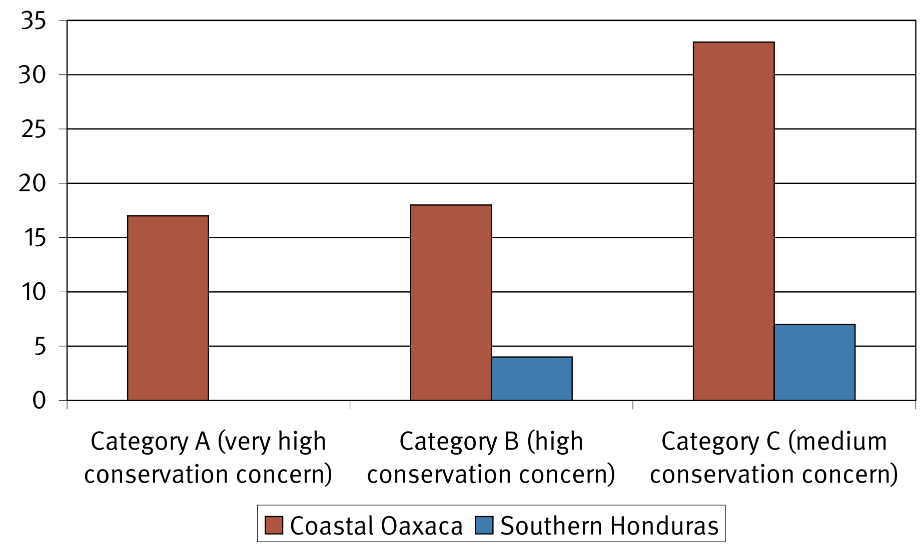
High bioquality deciduous forest on Cerro Guiengola, Oaxaca

11. The results in this chapter are discussed in more depth in Gordon et al., 2004.
12. Appendix 2 and 3 list the species of conservation concern in Oaxaca and southern Honduras respectively.

Box 6.1 *Swietenia humilis* – threatened or not?

In spite of the conservation concern suggested by the description of *S. humilis* (Honduras or small leaf mahogany) as 'vulnerable' by IUCN and its listing on appendix II of CITES, it was one of the most frequently encountered species in southern Honduras. It occurred in 51% of all samples and is well represented in all land uses except coffee plantations. The locally high timber value of this species means that farmers actively protect seedlings and saplings until they reach a size suitable for harvesting timber. This combined with its natural affinity for disturbance suggests that *S. humilis* will continue to persist in this landscape (Boshier et al., 2004). This leads us to question the assumption that felling a species for its timber is necessarily detrimental to the species' chance of survival. This assumption, in relation to international markets, is implicit in the listing of *S. humilis* in appendix II of CITES. Given also that it is of wide natural distribution, it might be that its status as an internationally protected species needs reappraising (Gordon et al., 2003).

Figure 6.1 Numbers of high conservation priority (restricted range) species in the two study areas



It should be noted, however, that the presence of such species should not be ruled out, as the present study only covered a sample of the area and did not include several dry interior valleys where rarity and endemism might be greater. Nonetheless, the consistently higher relative content of restricted range species found in the surveys carried out in Oaxaca, when compared to those carried out in Honduras, suggests that Oaxaca's MTDF is of greater global importance for the conservation of threatened tree diversity than that of Honduras.

Each of the botanical sample sites was allocated a Genetic Heat Index (GHI) value based on the numbers of high conservation priority species which it contained.[13] The results are illustrated in Figure 6.2 and reveal great variation in the numbers of high priority species between different land uses and sites. Perhaps not surprisingly, the least disturbed mature forest fragments of Oaxaca, together with some associated fallows, contain particularly large numbers of species of high global priority. The most obviously important area is the coastal belt of Oaxaca, between Huatulco and the western end of the Isthmus of Tehuantepec. Within this belt, four areas particularly stand out:

- Extensive tracts of mature deciduous forest on the coastal plain
- Deciduous forest on the steep hill of Cerro Guiengola
- Deciduous beach front forest
- Semi-deciduous forest on the steep hill of Cerro Huatulco

Coastal plain dry forest, Oaxaca

That sites such as Cerro Guiengola and Cerro Huatulco have well conserved forests is not unexpected. Their steep topography has protected both these hills from recent human activity. That this was not always the case, however, is evident from the precolombian ruin on Cerro Guiengola, which currently affords it further protection as an archaeological site. Cerro Huatulco too, is protected, as a Communally Managed Protected Area because of its importance as a source of water for the town of Santa Maria Huatulco. The beach front forest with its rocky slopes has also not been a site suited to intensive human activity – this is changing, however, as more tourists and more tourism development encroach upon unprotected parts of the coast.

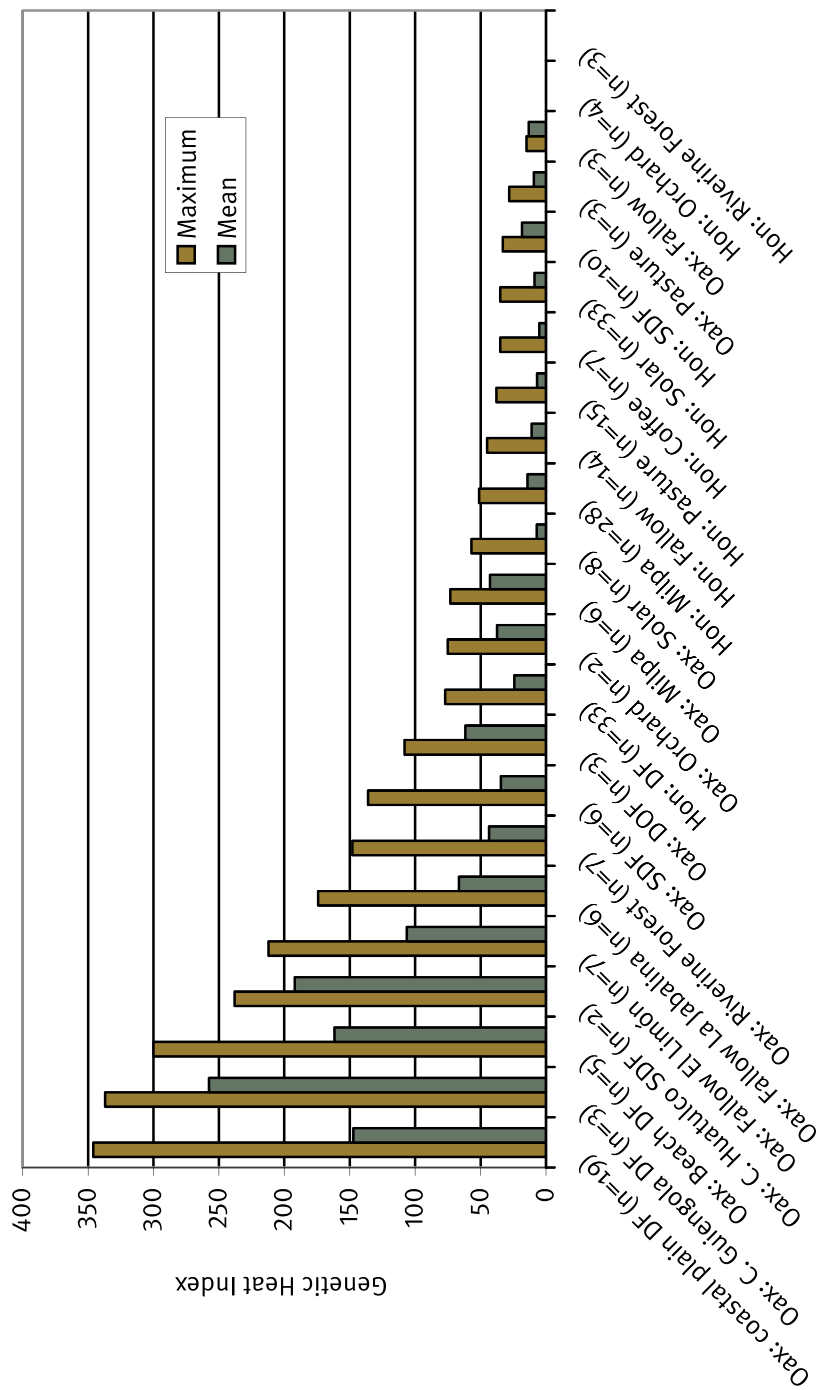
Deciduous beach front forest, Bahías de Huatulco, Oaxaca

Also notable in Oaxaca, and most interesting from a CTU perspective, is the large number of high priority species in a number of non-forest sites, located near areas of mature forest. Examples of such sites were found in the study communities of La Jabalina (close to the mature forests of Huatulco) and El Limón (close to Cerro Guiengola). This suggests that the communal forms of land ownership and management in this area may play an important role in facilitating their protection. Key elements include the long forest fallows that are an integral part of the land use system and the communal awareness of the collective importance

13. Appendix 1 provides details of how GHI is determined.

of natural resources that has led, for example, to the creation of a Communally Managed Protected Area in part of the forest around La Jabalina (Gordon et al., 2004).

Figure 6.2 Comparing the genetic heat index (GHI) of different land use types in coastal Oaxaca and southern Honduras



Different land use types in Oaxaca and southern Honduras (DF=deciduous forest; SDF=semi-deciduous forest; DOF=deciduous oak forest), where n = number of sample sites per land use type

The limited numbers of high global priority species in southern Honduras mean that this region has few, if any, sites or land uses of high global priority for the conservation of tree species diversity. In spite of extensive conversion of the original forest, this agroecosystem nevertheless plays an important role in conserving a large number of woody species, including many category B and C species, at little or no cost to conservation programmes. Our findings indicate that these species occur equally in all forms of land use (except homegardens, which are typically dominated by exotic fruit trees), as might be expected given the role of natural regeneration in determining tree species composition. The lack of land use specificity shown by these species, along with limited evidence that gene flow can be maintained between their fragmented populations (White and Boshier, 2000), suggests that they may continue to be conserved as long as land management practices continue to favour natural regeneration (Gordon et al., 2003).

Fragmentation, corridors and connectivity

Conservation biologists are concerned that, in the long term, the patches of forest left in typically fragmented dry forest landscapes may not, individually, be capable of sustaining all of the organisms they contain (Whittaker, 1998). One reason for this is that isolated populations are unlikely to contain all of the genetic variability of larger populations, reducing their ability to adapt to pests, diseases and other negative changes. Another reason is that unpredictable events, such as fires or pest outbreaks, may easily remove all of the individuals of a species from a small patch into which it is unlikely that it will be reintroduced through natural processes of dispersal because of its isolation from other sub-populations of the species. These fragmentation effects are especially severe in tropical ecosystems, where the existence of large numbers of different species means that most species are each only represented by a limited number of individuals. The fragmentation of Mesoamerican dry forest is particularly acute, increasing the risk of local species extinctions.

To mitigate the negative effects of fragmentation, much attention has been paid to the role that biological corridors might have in connecting fragments of forest and increasing their effective size. A biological corridor is typically visualised as a narrow band of habitat, similar in structure to two areas of conservation concern, which it connects. Our research indicates that the tree and shrub vegetation that grows up following clearance, in the areas surrounding surviving forest remnants, is in many cases of comparable species composition to the forest itself. Such areas, particularly (but not only) forest fallows, could therefore serve as connectors between more intact conservation areas. The typically mosaic-like nature of land use, in the agricultural landscapes where management involves the successive clearance and re-growth of mature fallow areas, may be compatible with reducing the effects of fragmentation. This supports the variable and dynamic interpretation of connectivity, as proposed by Gascon et al. (2004). They see corridors as consisting of biodiversity-friendly land uses that can be integrated with fragments of natural habitat in interconnected networks that help restore functional aspects of the landscape. Where the proportion of mature fallows is high, they may also be seen as a way of enlarging patches of mature forest, which is considered to be even more effective in increasing population size than the establishment of biological corridors (Falcy and Estades, 2007). Other forms of land use may have different roles to play. Scattered trees in fields and living fences may provide islands and corridors of suitable habitat between forested areas that facilitate movement of animals, seeds and pollen.

Conclusions: Consideration of global conservation priorities

As explained In Chapter 1, this study analysed priorities for conservation from a global perspective, on the basis of the relative geographical extent of the native ranges of the species in question. The analysis is also limited to tree and shrub biodiversity. The degree to which these conclusions hold for other groups of plants and for animals remains untested, although Gillespie and Walter (2001) provide evidence for species richness correlations between birds and woody vegetation elsewhere in Central American seasonally dry tropical forest. Acknowledging these caveats, the principal conclusions of the study in relation to conservation priorities in the MTDF are as follows:

- There is great variability between the study areas, and between sites within each study area, in their species composition and their global conservation importance. Broad-brush approaches to the conservation and management of tree species diversity, which do not account for these differences, should therefore be treated with caution.
- Mature forests, such as those that are found in coastal dry forest areas of Oaxaca in southern Mexico, appear to be particularly important for the conservation of tree species of high global priority. Strategies for the management and use of such areas should pay particular attention to promoting the conservation of these species.
- Many of the non-forest land-uses adjacent to these high priority mature forests, such as long-term fallows, also contain large numbers of high priority species. Protected areas containing high priority mature forests are typically small in size (compared to protected areas in many other parts of the tropics) and vulnerable. Particular attention should therefore also be paid to conserving species diversity outside of these areas in various land uses, both because such land uses may have high conservation priority in their own right and because of their importance in increasing the effective size of the mature forest reserves, which they abut.
- In comparison with the forested areas of southern Mexico, the dry forest agroecosystem, which dominates southern Honduras, contains few tree species of high global conservation priority. There is therefore more room for flexibility in the development of strategies for the management and use of tree species diversity because of the lesser risk of negative impacts on high priority species.

The conclusions presented here with regard to the Oaxaca study area may be broadly applicable to other areas of western and southern Mexico where similar conditions of land use and forest cover exist. Likewise, the southern Honduras study area may be broadly representative of areas on the Pacific slopes of neighbouring El Salvador and Nicaragua where a similar dry forest agroecosystem exists. Nevertheless, any recommendations from this study should not be applied more widely without locally specific verification.

One of the features of this study is the relatively high intensity of sampling carried out in the two study areas. Other surveys have attempted to draw conclusions for regional priorities in Mesoamerican dry forest by using much less intensive surveys. Given that we recognise that not all species in our two regions will have been encountered in our surveys, less intensive surveys are likely to omit even more species. There is, therefore, a very real danger that lower intensity surveys could lead to incorrect conclusions about conservation priorities (see Gordon and Newton, 2006b). The implication of this for conservation organisations is that using species surveys to determine conservation priorities, whilst highly desirable, requires a substantial level of funding if the results are to be reliable, especially when carried out over large areas.

Our methodology uses global range sizes to determine priorities amongst species. If consideration was limited to the range size *within a country* of each species, a type of national prioritisation would be possible. This may, however, result in scarce conservation funding being directed to species that are threatened within a country but common outside it. At local level, in the absence of information about the global conservation value of species, one approach to determining conservation priorities may be to consider trends in the relative supply and demand of the species.

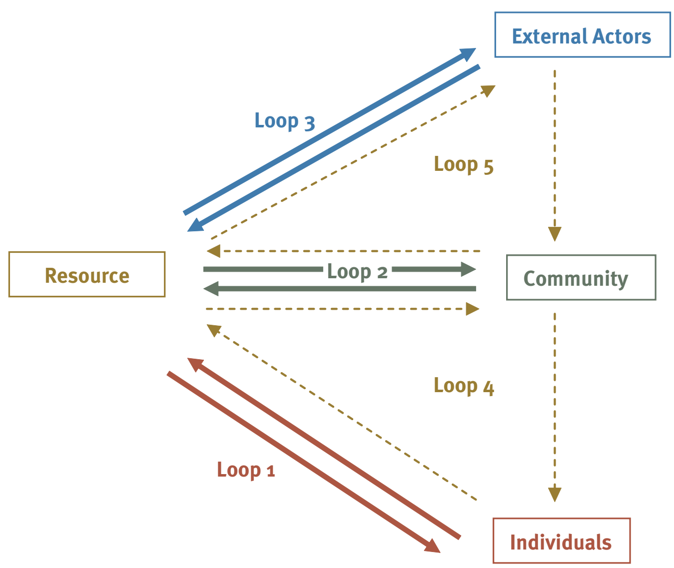
7. Assessing the potential of CTU in the MTDF

This chapter reviews the different forms that Conservation Through Use (CTU) can take, with examples from the study areas. It then examines our third research question relating to the circumstances under which CTU is an effective strategy for conservation of species and ecosystems, and considers how CTU can contribute to improving livelihoods.

Forms of CTU

In Chapter 1, CTU was defined as the 'conservation of any resource, motivated by perceptions of its utility'. The results of the studies carried out in southern Honduras and Oaxaca, presented in Chapters 4 and 5, show that CTU in the MTDF is occurring in a number of ways. In its simplest form, it is a loop: a resource provides a benefit to a user, who in turn conserves the resource. However, a number of different actors may be involved and benefits may reach the conservers directly or mediated by other actors, leading to the existence of a number of potential loops (Fig. 7.1).

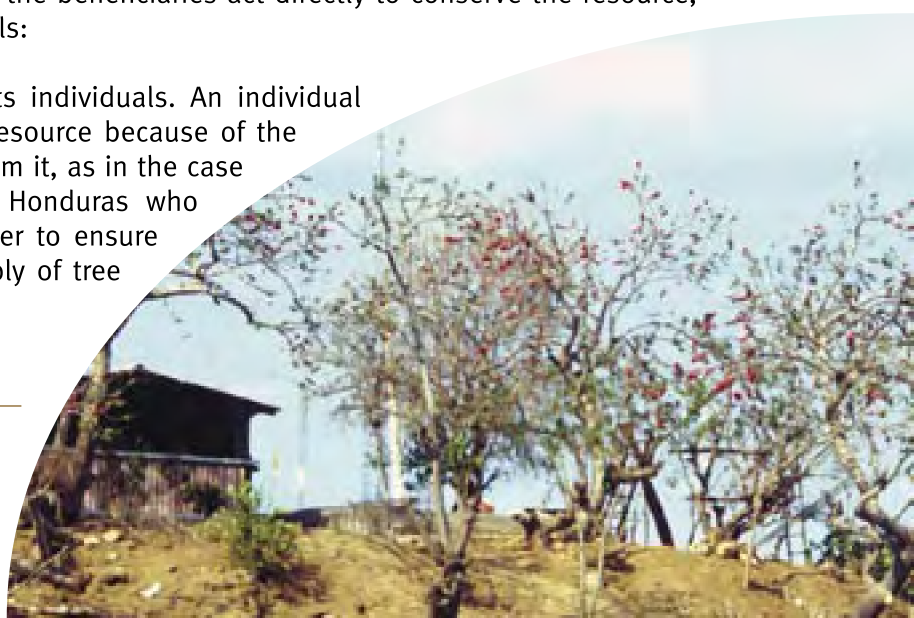
Figure 7.1 Alternative mechanisms of CTU



Direct CTU (loops 1-3)

Direct forms of CTU, whereby the beneficiaries act directly to conserve the resource, may occur at a number of levels:

Loop 1: Conservation benefits individuals. An individual is motivated to conserve a resource because of the benefits he or she derives from it, as in the case of the farmers in southern Honduras who protect trees in fields in order to ensure the maintenance of the supply of tree products (see Chapter 4).



Native dry forest trees (*Spondias purpurea*) that are widely cultivated for their fruit, southern Honduras

Loop 2: Conservation benefits communities. The community as a whole enjoys benefits from the resource, and as a result decides collectively to conserve it. This situation is found in some Mexican communities such as La Jabalina, El Limón and Petatengo. In all these cases the forest is a resource used by the community as a whole for the extraction of products essential for their livelihoods. In La Jabalina an added incentive is the potential of the forest to generate revenue for the community from ecotourism (see Chapter 5). While few if any management projects for timber have been developed in MTDF, the many community forest enterprises existing in other forest types in Mexico (Bray et al., 2005), particularly those in which timber is certified as sustainably managed, are further examples of this kind of CTU.

Loop 3: Conservation benefits external actors. The external actors may include, for example, downstream populations interested in the maintenance of watershed function, or international agencies interested in biodiversity conservation. In some cases, such as protected areas, these actors may be involved directly in the management of the resource. In La Jabalina, Oaxaca, for example, the Huatulco National Park was established by the Federal Government to protect globally important biodiversity (see Box 5.2).

Indirect CTU (loops 4 and 5)

Indirect CTU occurs when the beneficiaries act through others to ensure conservation of the resource.

Loop 4: Benefits to communities result in conservation by individuals. The community as a whole brings about conservation by influencing the actions of its individual members. This can be achieved either through the provision of incentives in the form of distributed benefits and/or through coercion in the form of community regulation. In La Jabalina, El Limón and Petatengo, Oaxaca, Loops 2 and 4 both apply (see Chapter 5): the decision to conserve forest resources for the good of the community as a whole has led both to communal actions, such as the fencing and signposting of communal forests (Loop 2) and individual actions such as the avoidance of felling and burning because of the threat of sanction and the perception of individual benefits (Loop 4).

Community members are conserving coastal dry forest near Huatulco beach in the hope that they will be paid for its hydrological services by a new hotel complex

Loop 5: Benefits to external actors lead to conservation by local actors. Increasingly, local actors are being involved in conservation even when the values protected are principally of interest to external actors. Again, the two options of incentives and coercion apply: external agencies either pay local actors (communities or individuals) to conserve for them the resource that they value, or promote regulations to prevent local actors degrading the resource, if the incentive is not sufficient. This is the case in Petatengo, Oaxaca, where the prospect of payment for the hydrological services provided to the Bahías de Huatulco hotel complex is one of the factors motivating forest and watershed conservation by community members (see Box 5.1).

In the ideal situation – from the point of view of external actors interested in the conservation of a resource – a resource is of sufficient value to local actors to motivate them to conserve it in the long term, incidentally conserving global values at the same time. Here, loops 1 or 2 and loop 3 apply at the same time, without the need for incentives or coercion.

Can CTU be relied upon for the conservation of rare tree species?

Species level CTU

Very few species of high conservation priority are actively used or individually protected through CTU

CTU at the species level refers to situations where actions are taken to protect populations of particular species because of their perceived utility. In Chapter 6, it was shown that 78 of the species found in the two study areas are of significant global conservation priority. However only three of these species (3.8%) were reported by farmers as being actively used (Table 7.1) and only one of these (*B. quinata*) was reported as being actively protected at a species level.

Table 7.1 Species of high global conservation priority that were also reported as being used

Species	Status and location	Use
Brongnartia bracteolata	Category B (Oaxaca)	Reported by five interviewees (6%) as used for timber
Bucida macrostachya	Category C (Oaxaca)	Reported by only one interviewee as used for timber
Bombacopsis quinata	IUCN vulnerable (Honduras)	Among the 10 species most reported as used for timber in the Honduras study communities (see Table 4.1).

Even in the case of *B. quinata*, the one high priority, actively used and actively protected species found, CTU is infrequent. Only 2 people out of the 79 interviewed in southern Honduras reported actively protecting it in their fields, as compared to 30 in the case of *Cordia alliodora* (see Table 4.7). In the community of Los Coyotes, as *B. quinata* has become progressively scarcer, instead of conserving it farmers have switched to using other species, such as *C. alliodora*, whose timber is a suitable if not perfect substitute for *B. quinata*. Farmers' failure effectively to conserve *B. quinata,* despite its value to them, may be explained by this species' limited ability to regenerate and compete in agricultural fields, in comparison with, for example, *C. alliodora* or *Swietenia humilis* (Box 6.1). As a result, it is more commonly found in small woodland areas, for example along streams, than in farmers' fields. These small woodland areas tend to be of open access and subject to illegal tree felling, with the result that the conservation status of *B. quinata* is far from secure.

The evidence presented in the preceding chapters indicates that species level CTU contributes little to the conservation of species of high global conservation priority, at least in the two study areas. However, the example of *L. salvadorensis* suggests that it would be a mistake to rule out completely the potential of species level CTU for global conservation. The patchy nature of the natural distribution of this species means that, by chance, it was not found in any of the communities included in this study. *L. salvadorensis* is a Category B species (of second highest conservation priority in terms of global rarity), which is thought only to occur on the Pacific drainage of eastern El Salvador, southern Honduras and western Nicaragua (Hughes, 1998). Where it does occur, however, it is highly valued by farmers as a source of durable posts and is frequently protected in fields (Hellin and Hughes, 1993) where, in contrast to *B. quinata*, it regenerates and competes well. Although no reliable information is available on trends over time in the population numbers of *L. salvadorensis,* it is probable that this active protection in fields contributes significantly to the numbers of individuals in the landscape that are able to reach reproductive age.

The practice of protecting useful trees in fields (a form of CTU) is relatively common in southern Honduras, where off-farm sources of tree products are hard to come by because of reduced areas of forest and fallow. By contrast, the practice is almost unknown in the communities studied in Oaxaca, most of which still contain significant areas of forest and fallow from which the population can obtain tree products. This difference suggests that the practice of species level CTU in fields is directly motivated by the threat of scarcity of off-farm tree products and that, conversely, off-farm product abundance is a disincentive to on-farm tree conservation. From the conservation perspective, this implies that species level CTU in fields constitutes a 'last-ditch' solution, which may only come into play when, as in the case of southern Honduras, much of the off-farm resource and most, if not all, of the species of high conservation concern that may have existed in it have been lost.

However, the case of El Sanjón, in Oaxaca, shows that even when off-farm trees and forests have largely disappeared, species level CTU in farmers' fields does not necessarily occur and therefore cannot be relied on for the conservation of species of high conservation priority. As we have seen, farmers in the flat lands of El Sanjón rarely protect trees in fields for two reasons: firstly, they have relatively good access to sources of income, which enables them to purchase fuel and building materials rather than relying on collecting them from on-farm trees; and secondly, the suitability of their lands for lemon production means that any trees retained on farm would have a significant opportunity cost in terms of the lost space for lemon trees. A suggestion by Mendez et al. (2007) is that certain types of certification could provide new incentives for species level CTU. Coffee farmers in El Salvador, for example, seem to show an interest in maintaining tree species of conservation concern in their plantations because this may allow them to obtain shade certifications, that can result in price premiums for their coffee; and also because these trees are attractive to ecotourists (Mendez et al., 2007).

The above examples suggest that species level CTU can only contribute to the conservation of tree species diversity in the case of species with a very specific set of characteristics:

Characteristics of species that could benefit from species level CTU:

- Of high conservation priority;
- Of sufficient value to farmers to motivate them to invest in protection, even if this involves negative impacts on crops or other costs;
- With uses which lend themselves to sustainable management (such as fruit, which does not entail felling of the tree, or timber if the species is prolific or vigorous enough to allow extraction to be compensated for by regeneration);
- With uses which cannot easily be provided by substitute species;
- With the ability to regenerate and compete in highly disturbed agricultural environments (particularly for timber trees, which farmers tend to maintain in their fields rather than the more protected homegarden environment).

In addition, species level CTU is more likely to be successful if the following socioeconomic and environmental conditions apply:

Conditions under which CTU may contribute to conservation at the species level:

- Secure individual long-term rights to tree use;
- High levels of demand or need, either for subsistence use or for sale, for the goods and services produced by the tree (in the case of sale, this implies easy market access);
- Scarcity of the products and services provided by the species in question;
- Low levels of opportunity cost associated with tree management, e.g. when combined with low value crops or shade resistant crops;
- Awareness on the part of farmers of the silvicultural potential and yield of the species involved;
- A favourable regulatory context, which minimises the restrictions and administrative difficulties associated with marketing tree products (this may require the decentralisation of controls and the strengthening of social auditing, in order to avoid abuses);
- A biophysical environment which is favourable to tree regeneration; this may, for example, largely rule out many flat lands where mechanised cultivation is used.

The case of *B. quinata* underlines the need for all of the above conditions to be met simultaneously; the existence of market demand for a species is not enough to guarantee its conservation and may, in fact, have the opposite effect if the species in question does not regenerate easily.

Ecosystem level CTU

CTU at the ecosystem level refers to situations where actions are taken to protect an ecosystem (e.g. a forest) as a whole, because of perceptions of its utility and value, for example as a source of useful species or of environmental services. Several of the examples in Oaxaca, reported in Chapter 5, suggest that CTU has potential at an ecosystem level. Forest conservation by communities in Santa María Huatulco, (including the establishment of communal reserves and the application of restrictions on the clearance of high forest and on the use of fire for agricultural site preparation) has been motivated by both its perceived role in protecting water supplies and its potential for revenue generation, through ecotourism and the sale of environmental services. Were it not for these measures, it is probable that significant areas of forest would have been cleared, either permanently or temporarily, for agriculture and cattle ranching, as the rural population grew. Ecosystem level CTU in this case is of both local and global significance: as well as being highly valued and therefore protected by local communities, the forests affected contain large numbers of species of high global conservation priority.

Our research suggests that a specific set of conditions must simultaneously be met for ecosystem level CTU to work:

Conditions under which CTU may contribute to conservation at the ecosystem level:

- The goods and services produced by the ecosystem confer greater benefits on those who are responsible for its management than alternative land uses. This implies the existence of a need or demand for the goods and services and, where the benefits are financial, functioning markets;
- The ecosystem has the long-term capacity to produce the goods and services which motivate investments in its conservation;
- The goods and services produced by the ecosystem are compatible with the long-term conservation of its individual components (e.g. species) of high conservation priority;
- Effective structures exist for formulating and enforcing regulations, based on awareness of the condition and potential of the resource in question.

The above conditions are met in the cases of parts of La Jabalina and, to a large extent, Petatengo. They are not met in El Sanjón, where forest conservation cannot compete with lemon production, or in some situations in El Limón, where the effectiveness of community regulation in the enclosures of individual *ejido* members is limited.

As long as they are not adversely affected by the use given to the ecosystem, the particular characteristics of high conservation priority species are less critical with CTU at ecosystem level than at species level. Indeed, most of the high priority species currently conserved in Oaxacan forests are incidental 'free riders' which are not valued individually but benefit from the perceived value, and the resulting conservation, of the forest as a whole.

Indications on the potential of ecosystem-level CTU, from the dry forest communities of coastal Oaxaca included in this study, cannot necessarily be generalised widely to national level or to other forest types, particularly when forest use is based on the commercial extraction of timber. A study of 450 Mexican *ejidos*, for example, found that communities practising commercial forestry had difficulties preventing encroachment, especially by non-members of the *ejidos* (Alix-Garcia et al., 2005). Nevertheless, based on a comparison of land use change in Mexico's protected areas and 22 *ejidos* in Guerrero and Quintana Roo, Durán-Medina et al. (2005) consider well-organised *ejidos* that have developed a community-based forestry plan to be among the conservation scenarios with the greatest long-term potential. More generally, Hayes (2006) presents evidence from thirteen countries around the world for the effectiveness of forest conservation when governed by 'users who establish and recognise forest rules'.

Can CTU contribute to improving livelihoods?

In all of the cases of CTU presented here, the driving force has been the desire of local communities or individual farmers to promote their livelihoods, by ensuring the continued supply of subsistence products or environmental services, or through generating income. However the degree to which CTU succeeds in meeting these objectives consistently and in the long term, varies a great deal.

Tree level CTU and livelihoods

The fact that most of the informants in the study communities in Honduras reported that they enjoy adequate access to tree products (see Tables 5.3 and 5.4), despite the limited areas of forest and fallow remaining there, suggests that CTU, in the form of the protection of trees in fields, has to date been largely effective with respect to this aspect of farmers' livelihoods. Farmers have responded to the decreasing availability of tree products in fallows and forests by protecting trees such as *C. alliodora* within their fields as a source of products. Under favourable conditions, such as the good access to markets for tree products enjoyed by the population of Los Coyotes, the protection of trees in fields can be highly profitable compared to agricultural income.

A. adstringens with signs of bark harvesting, Oaxaca

Two of the cases examined in the case study chapters, however, demonstrate that farmers' preference for a tree resource does not always lead to successful CTU. Thus, the limited ability of *B. quinata* to regenerate and compete in agricultural environments has resulted in farmers in Los Coyotes, Honduras, having decreased access to this species and being obliged to use other species of inferior quality. In El Limón, Oaxaca, the limited effectiveness of community-based controls over farmers' management of resources within their individual plots has led to the over-exploitation of *A. adstringens* bark. It remains to be seen whether *A. adstringens* will continue to decline locally or whether, given the existing conditions of individual tenure and secure use rights, and the ready coppicing ability of this species, farmers will be motivated to take active measures to protect the resource once a certain level of scarcity is reached.

Conditions under which tree level CTU may contribute to livelihoods:

- Large numbers of individuals (including seeds, seedlings and stumps) of species which yield useful products and services, can regenerate easily in fields and tolerate pruning and other management activities;
- Access to markets (either within or outside the community) for the tree products;
- Secure individual long-term rights to tree use;
- A favourable regulatory context for sustainable exploitation;

- An environment which is favourable to tree regeneration (for example without excessive intensity of burning or soil compaction).

Although the CTU of certain tree species may contribute to farmers' livelihoods, the range of species found in farmers' fields and fallows, and the relative proportions of each, tend to vary widely from place to place in the MTDF. Before assuming that CTU can be depended on to contribute to livelihoods in any given site, it is necessary first to carry out field assessments of the types of species present and the numbers of each. Such assessments should examine not only fully developed trees but also live stumps and seedlings, which can make up the vast majority of the individuals present in the agroecosystem (see Box 4.2).

Ecosystem level CTU and livelihoods

The effectiveness of ecosystem level CTU in contributing to farmers' livelihoods also varies from place to place, as shown by the contrasts between the study communities in Oaxaca. In Santa María Huatulco, community-based control is apparently effective in ensuring the survival of communal forests from which community members obtain their water supply, even though anticipated income from ecotourism and the payment for environmental services has yet to be fully realised.

Meanwhile in Petatengo (also in Oaxaca), efforts by a local NGO to promote sustainable forest management and timber harvesting, as a source of income and to increase community members' valuation and therefore conservation of communal forests, has encountered some resistance among certain sectors of the community (see Box 5.1). Like Santa María Huatulco, Petatengo also has strong community-based control structures. An important difference between the two, however, is that in Santa Marìa Huatulco the proposed income-generating activities are non-extractive whereas those in Petatengo are extractive and, therefore, have the potential to affect the condition of the communal resource. The Petatengo case suggests that, on communal lands, commercially-oriented extractive uses can generate conflicts about how individual benefits may affect the interests of the community as a whole which need to be addressed with particular care.

Conditions under which ecosystem level CTU may contribute to livelihoods:

- Physical characteristics of the ecosystem, which enable it to contribute to livelihoods through the provision of goods and services;
- Appreciation by the people who manage the ecosystem of its provision of, or potential to provide, products and services;
- Compatibility of the enjoyment of the products and services with the long-term conservation of the resource;
- Effective mechanisms for the distribution of the benefits and/or the compensation of the costs of conservation to those who invest in it;
- Effective mechanisms for the participation of those who receive products and services from the resource in decisions relating to its management;
- Effective regulation of the management and use of the resource.

Conclusions

To summarise, the case studies have demonstrated a number of different forms of CTU in action. They can be distinguished in terms of whether the person or people benefiting from the conservation are directly or indirectly responsible for implementing conservation activities, whether CTU is ensured through regulation and/or incentives, and by whether species or ecosystems are the object of conservation.

From the point of view of the conservationist interested in globally important tree and shrub diversity, species level CTU is currently not of great significance as very few tree and shrub species of conservation concern are of sufficient interest to farmers to warrant active protection. CTU at ecosystem level appears to have more potential, at least in areas with large numbers of high conservation priority species, because it leads to the conservation of the forest ecosystem as a whole (in our examples) and thereby of the priority species within it, irrespective of their individual importance to local people.

From the point of view of local populations keen on improving their livelihoods, the success of both species and ecosystem level CTU depends on a number of factors including secure tenure and access to markets for the products (or services) of the species or forests concerned. While decisions about species level CTU can be taken by individual farmers, ecosystem level CTU may be more complicated because it more commonly involves decision-making and benefit-sharing at community level.

In the next and final chapter we discuss the circumstances under which CTU is particularly appropriate and make specific recommendations for the study areas.

8. Recommendations for implementing CTU in Mesoamerican tropical dry forest

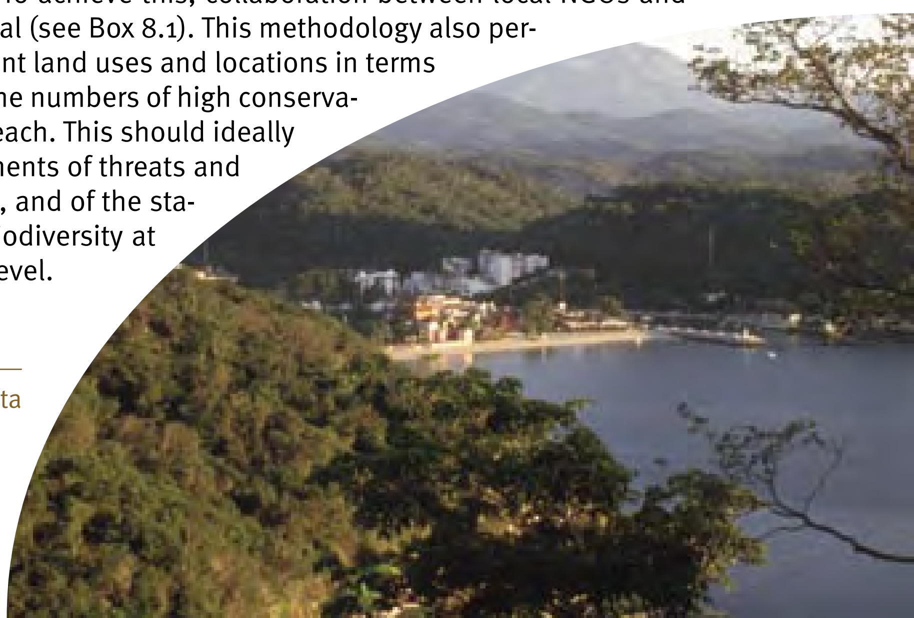
The previous chapters have shown that conservation through use can be effective if certain conditions are met. In this chapter we set out the steps which decision makers in the Mesoamerican tropical dry forest need to take in order to determine when they can rely on CTU to meet their objectives; and how to help sustain or create the conditions for it to work. We then set out priorities for action specific to the two study areas.

When to promote CTU

There are many alternative approaches to conservation, both competing and complementary. It is therefore increasingly important for governments and conservation NGOs to assign the limited resources available in a rational manner. As we have seen in the preceding chapters, CTU may already be conserving species and ecosystems in some areas. In an ideal world, CTU would be self-sustaining, as the benefits from conservation motivate further conservation (see Chapter 1). However, the relationships between local farmers or communities and their natural resources are highly variable and dynamic. Below we outline very briefly some of the steps necessary to determine whether and where CTU has a role.[14] While our focus in this book has been on global conservation priorities, similar steps are also useful for deciding on conservation initiatives at a more local level.

(i) Determine which species, types of vegetation or specific areas of vegetation are of greatest global conservation concern: is there a global justification for investing in CTU?

As a starting point, important sources of information include the IUCN Red List of endangered species (http://www.redlist.org/) and the WWF Global 200 list of the world's most biologically outstanding habitats (Olson et al., 2001). These can be supplemented by local checklists such as the one provided in Appendix 4. A relatively rapid and low cost methodology for comparing the conservation priorities of large numbers of other species is presented in Chapter 3 and Appendix 1. To achieve this, collaboration between local NGOs and herbaria is likely to be essential (see Box 8.1). This methodology also permits the comparison of different land uses and locations in terms of their bioquality, based on the numbers of high conservation priority species found in each. This should ideally be complemented by assessments of threats and trends in population numbers, and of the status of other components of biodiversity at both species and ecosystem level.



Beach resort in dry forest, Santa Cruz Huatulco, Mexico

14. See also suggestions for further reading in Appendix 6

For each species or habitat of conservation concern, conservation priorities need to be made explicit (e.g. increasing the numbers of a particular species or improving its age structure or conserving a particular ecosystem) so that specific management objectives can be formulated (Hamilton and Hamilton, 2006).

Box 8.1 Improving links between NGOs and herbaria

For conservation oriented NGOs working in the field, it is vitally important to know which species are present in their locality, and which of these are priorities for conservation. However, tropical floras in developing countries are typically poorly known and resources to fund botanists often limited. The few botanists capable of helping NGOs are usually concentrated in city-based herbaria. NGOs can encourage such institutions to be more responsive to their needs by:

- *Collecting existing botanical information for the region.* Despite a lack of information on local species, much can be found in published literature about the importance of vegetation types in a region of interest, and of the importance of the floras of similar forest types from published checklists. With this kind of information, a herbarium-based botanist is more likely to be interested in forging links with an NGO.
- *Budgeting for plant identification services.* Plant identification is a skill that may have to be paid for. NGOs cannot assume that such services can be supplied without cost. Funding proposals need to budget for such services. Rapid botanical surveys may take a relatively short amount of time in the field, but *at least* an equal amount of time should be expected for species identification in the herbarium.
- *Training staff in basic collection techniques.* With relatively little training, locally based staff can become 'parataxonomists' and take on much of the fieldwork. The key to this is to understand basic collecting techniques. With good botanical collections, pressed, dried and sent, along with field notes, to the herbarium, the botanist can dedicate his or her relatively expensive time to specimen identification alone. It may therefore only require one brief field visit for the botanist to train local staff.
- *Demonstrating a long-term commitment to conservation.* A herbarium is more likely to be interested in collaborating with an NGO if that NGO can demonstrate a long-term commitment to local conservation in its planning processes.

Good botanical specimens facilitate identification in the herbarium

(ii) Determine what value the species or ecosystem has for local people: is there a 'use' on which to base CTU?

This is likely to vary between different forest types, socioeconomic groups, forms of resource users and ethnic groups. If no previous studies exist in the area, a number of methodologies are available for collecting the information required, including questionnaires, semi-structured interviews and participatory rural appraisal (PRA) tools such as species ranking matrices (Pretty et al., 1995; Geilfus, 2000). The choice of the methodologies applied may depend on the balance required between quantitative and qualitative information, and the size of the human population to be covered.

Where individual species have no evident 'use' value, they may nevertheless be conserved within a land use or forest ecosystem that people are conserving for some other reason (essentially as 'free riders').

(iii) Determine whether the benefits that local people receive from trees and forests are under threat: is there a local motivation for CTU?

Local people are only likely to carry out CTU if they recognise that the trees and forests which provide them with benefits are under threat, and that they have no other means of obtaining the benefits than conserving the particular trees and forests in question. It is therefore important to determine, in conjunction with local people, whether forest cover, the frequency of individual species and the availability of tree products are changing over time; how the use of the species/ecosystem fits into farmers' livelihoods; and whether the species which people currently depend on are unique in their usefulness, or could easily be substituted by other species (thereby avoiding the inconvenience and opportunity cost which might be implied by taking conservation measures, such as accepting shade on their crops, or 'setting-aside' areas of communal forest). This type of information can normally only be obtained by participatory socioeconomic research at farm and community levels, involving as appropriate semi-structured interviews and PRA tools such as time lines or ranking matrices. Such assessments need to include a gender element as changes in availability and quality may have different implications for men and women.

Women in Agua Zarca, southern Honduras, still make soap from the seeds of *aceituno* (*Simarouba glauca*) but easy access to purchased soaps means there is little motivation to conserve this species in other communities

(iv) Determine the social and institutional context for resource management: what are the factors that affect farmers' decisions on how to manage the resource?

As we have seen, CTU at species level is frequently determined by the decisions taken by individual farmers, whereas ecosystem-level CTU is more likely to depend on decision-making at community level. To understand how farmers and communities take these decisions, as the basis for the development of CTU strategies, necessary information may include the nature of tenure and usufruct rights (e.g. formal rights backed up by titles versus informal but locally recognised rights), the main components of local land use and agricultural production systems (including markets), and the extent to which individual decision-making is constrained by community-level decisions (for example through cultural norms or formal regulations). In the case of communal resources, it is also important to understand the nature of the mechanisms for sharing costs and benefits between community members, and local enforcement of rules. Useful tools for gathering such location-specific information on natural resource decision-making by farmers and communities include focus groups and semi-structured interviews as well as field visits with farmers and other resource users.

(v) Characterise the factors that determine sustainability of CTU: is it likely to be sustainable in the long term?

Smallholder farming systems in the MTDF are typically highly complex and dynamic. In order to define strategies for CTU which are likely to be sustainable in ecological, socio-economic and political terms, it is necessary to understand the pressures acting on farming and livelihood systems, the ways in which they respond to these pressures (which in turn will depend on the inherent characteristics of the resource and its stakeholders) and trends over time in these pressures and responses (Barrance et al., 2006).

The long-term ecological sustainability of use is likely to depend on the nature of the use itself (for example does it imply killing the tree or otherwise reducing its ability to compete or reproduce?), its magnitude (how does the rate of removal of individuals compare with the rate of regeneration?) and the nature of the resource affected (is it abundant, does it reproduce or resprout easily, does it tolerate disturbed conditions?). Much of this information may be provided by simple field observations, together, where possible, with comparative timeline analyses carried out with local people looking at how historical trends in levels of use have related to trends in abundance of the species in question. This may be complemented, where necessary and possible, by quantitative field inventory of population numbers and size classes, preferably carried out in a participatory manner in order to equip local people with the tools and capacities to define and monitor acceptable use levels.

Socio-economic factors relate to population movements, changes in agricultural production systems and other livelihood opportunities, and market trends for the products of ‘useful’ species or ecosystems and any substitutes. Broad-brush information, e.g. on population size and trends in the production of specific crops and in farm size, can be found in population and agricultural censuses. PRA tools such as timelines may be useful to provide more locally specific indications of the timing and general directions of trends. Aerial photographs can provide very useful and locally specific indications of trends but quantification of trends in parameters such as field sizes is laborious, and it is sometimes difficult to obtain photographs over the required time period. Satellite imagery can also be very useful, for example in showing trends in vegetation cover and condition. Market surveys are needed to determine trends in prices and volumes of traded products.

Political factors broadly include land tenure, access regimes and enforcement. Information on regulations and policies, which affect how farmers and other resource users manage trees and forests and which may favour or hinder CTU, can be collected relatively easily through a review of laws and policy documents. However it is also important to assess how such instruments are interpreted and applied locally, as this may differ greatly from what was originally intended. Such information can be gathered through local focus group meetings and semi-structured interviews.

How to promote CTU

It is important to realise that recognition and support of existing CTU may be as important as promotion of new CTU initiatives. To define appropriate support and promotion activities, it is first necessary to determine the scale at which action will be taken. Depending on the type of CTU being promoted, the focus of action might be individual farmers, communities or a combination of the two. Particularly in the case of mosaic agroecosystems in which species of high conservation value are found in both mature forest fragments and forest fallows, landscape or ecosystem approaches (Sayer and Maginnis, 2005) might be most appropriate, possibly involving interaction with various administrative layers. Secondly, it is important to be aware of the balance of costs and benefits arising from CTU. Understanding who bears the costs of CTU and who receives direct or indirect benefits (see Fig 7.1) will determine whether it should be accompanied by measures to improve the equity of benefit distribution or to compensate for possible negative impacts on the interests of any stakeholder group.

Taking into account scale and cost/benefits as well as the findings of the assessments set out in the previous section, promotion activities fall into three main groups:

(i) Regulations

Regulation and control are a necessary, though not sufficient, condition for sustainable use (Hutton and Leader-Williams, 2003). Gibson et al. (2005) argue that enforcement by local user groups of rules on extraction is the most important condition for ensuring effective resource management as it counteracts the temptation for individuals to 'defect' or take more than is allowed. In the broadest sense, this includes some or all the following:

- *Promoting tenure and usufruct rights.* Influence may be brought to bear on the formulation of local, national and international laws, regulations and conventions, in order that local people can feel unambiguously secure that they will be assured of use benefits as a result of any resource conservation activities they carry out.
- *Developing awareness and strengthening community organisation.* The non-use value of forests to local people is often a product of traditional knowledge and environmental customs. This may be enhanced by community development activities (including participatory research, documentation of customary knowledge and environmental education), and the promotion of a supportive legal framework. It is also important to support the decision-making and regulatory structures required to ensure that individuals' actions are in the community's best interests.
- *Promote benefit distribution mechanisms.* In order to ensure that those who determine how the resource is managed feel motivated to participate in its conservation, transparent and efficient mechanisms are required for the equitable and effective distribution of benefits. In reality, certain groups of resource users can influence how others use and benefit from the resource through regulation (see Loop 4 in Figure 7.1). An example is that of *ejido* members in Mexican communities who, because they value

the resource, regulate its use by non-*ejido* members. From the conservation viewpoint, it is not necessary for members and non-members to receive the same benefits. However, for CTU to be socially sustainable, it is desirable for all resource users to participate in some way in resource management decisions, and to receive a corresponding share of the benefits.

- *Streamlining regulations.* Increasing the regulatory burden (through new rules or better enforcement of existing ones) on poor farmers may have the perverse impact of marginalising them into illegality (Schreckenberg and Bird, 2006). It may instead be more effective to reduce the time and costs of obtaining timber felling and transport permits to increase the attraction to farmers of managing certain timber species, as long as sufficient regulations and other controls are still maintained to prevent abuse. With respect to community-based forest management, Menzies (2007) argues that it is counterproductive to impose regulatory frameworks constraining the role of community institutions to the extent that the perceived extra burden of forest management outweighs the benefits to the community, undermining the incentive to care for the resource as a valuable community asset.

(ii) Incentives

Positive incentives tend to be more powerful and cost effective than a regulatory system that relies primarily on negative incentives (Murphree, 2003). Examples include:

- *Research and promotion of income generation activities.* Communities may require training and assistance in order to take advantage of certain forms of resource use that lend themselves to CTU, such as ecotourism, the sale of environmental services and NTFP production.
- *Promotion of processing and marketing opportunities.* The value to local people of many species of high global conservation importance is limited by their inability to add value locally to the species' products or to market them competitively. Local processing can be encouraged by the promotion of appropriate local technology and training. This needs to be supplemented by market research into the potential demand for new products or qualities (e.g. the properties of lesser known timbers and how best to introduce them into traditionally conservative markets), provision of marketing skills and the support of marketing infrastructure and information systems.

These forms of 'in kind' incentives, aimed at capacity building, are likely to have more sustainable impacts in the long term than financial or material incentives which in the past have been used by many development and conservation projects in order to influence farmers' behaviour.

(iii) Monitoring effectiveness

As was suggested in Box 1.1, there is a risk that some forms of CTU may prove unsustainable, leading to a progressive decline in the resource affected. It is therefore important that the promotion of CTU is accompanied by adequate provisions for monitoring the effectiveness of the strategies applied and agreed mechanisms to amend them as necessary. Factors to be monitored may relate to the species being conserved, such as total population numbers and population structures (e.g. relative proportions of different age classes), or to the ecosystem concerned, such as the area covered and its composition in terms of species and size classes. It may also be important to monitor socio-economic factors such as how the activity is affecting the interests of different stakeholders, relative to the benefits they receive.

Priorities for action in the case study areas and similar sites

General priorities for conservation in the MTDF

In order to maximise the impact of the resources available globally for conservation, initiatives aimed at conserving MTDF tree species diversity should focus primarily on mature forest patches of high bioquality such as those of coastal Oaxaca (see Chapter 6), rather than agroecosystems of relatively low bioquality such as those of southern Honduras. Actions focused in this way on specific sites with high bioquality are likely to offer better value for money in global terms than transnational biological corridors, which encompass large areas of low bioquality.

It is probable, but should not be assumed, that much of the rest of the highly disturbed agroecosystem of the Pacific slope of Central America has similarly low bioquality to southern Honduras, in terms of tree species, and that investments there would have similarly limited impacts on the conservation status of globally rare species, compared with areas of proven high bioquality such as coastal Oaxaca. Whilst we speculate that the differences between bioquality between southern Honduras and Oaxaca are at least partially a result of greater disturbance and conversion in the former, this does not mean that all highly disturbed dry forests in Mesoamerica have low bioquality. The only reliable way to determine variation in bioquality is by comparative sampling, as we carried out here.

Although the great majority of the globally important tree species in the MTDF are found in high bioquality areas such as those in coastal Oaxaca, a few (such as *Bombacopsis quinata* and *Leucaena salvadorensis*) are found only in low bioquality agroecosystems. While *L. salvadorensis* appears to survive reasonably well under these conditions, specific conservation strategies are needed for the very few globally rare species (such as *B. quinata*) which are not well represented in conservable mature forest fragments and do not prosper in agroecosystems. As a last resort, complementary *ex situ* conservation measures may be considered for these species.

Priorities in the southern Honduras case study area

Actions related to promoting CTU in the dry zone of southern Honduras should focus principally on its potential contribution to livelihood support, because of the high levels of poverty, the limited livelihood support options open to its population and their heavy dependence on tree products, combined with the low bioquality of this area. At the same time, it is important to promote the conservation of the few species of high global priority that exist there, such as *L. salvadorensis*, for example through promoting awareness of their conservation status and management options among local conservation and development organisations.

The following specific actions could be taken, in order to realise the potential of CTU to contribute to rural livelihoods in the area:

1. Streamlining of regulations and procedures governing the harvesting and marketing of trees which regenerate naturally in agroecosystems, in order to make it more attractive for farmers to manage trees as an easily-saleable cash crop.
2. Promotion of local (municipal and community) level control over the harvesting and marketing of trees which regenerate naturally in agroecosystems, accompanied by provisions for local social auditing.
3. Participatory activities to assist farmers to appreciate the potential of CTU to contribute to their livelihoods, and the potential compatibility of naturally regenerated trees in fields with agricultural practices.
4. Promotion of markets and local processing facilities for timber coming from naturally regenerated trees in agroecosystems (subject to the introduction of effective, streamlined local controls).

These recommendations are likely to be applicable in general terms throughout much of the Central American dry forest agroecosystem, particularly in central and eastern El Salvador, the southern parts of the departments of Intibucá and Lempira in western Honduras, and much of western Nicaragua, as broadly similar conditions of resource scarcity and tree tenure exist throughout this area (indeed, first hand observations indicate that there is evidence of similar species level CTU being carried out in each of these areas). The broad similarity between the four Honduran study communities in terms of the functioning of species-level CTU, despite variations in altitude, rainfall, access and production systems, suggest that these factors have relatively little effect on the replicability of these recommendations.

There is however much variation in local-level conditions. The conclusions presented here with regard to species-level CTU do not necessarily apply to:

- large land holdings whose owners' livelihoods are not significantly affected by the scarcity of tree products;
- areas such as flat lowlands with potential for irrigation, where, it is possible to produce high-value crops, and there is therefore a high opportunity cost associated with tree conservation; or
- areas where the tradition of using fire to clear vegetation or control pests inhibits natural regeneration.

Priorities in the Coastal Oaxaca case study area

In order to conserve tree species of global conservation priority, particular attention should be paid to the conservation of the largely intact forests and mature fallows of coastal Oaxaca, especially those between Huatulco and the western end of the Isthmus of Tehuantepec. High bioquality patches in these areas should be managed as part of the wider agroecosystem in order to increase their effective size and maximise the gene flow between them. This means that conservation approaches must go beyond promoting conservation of isolated forest patches, and work with the intervening landowners, including consideration of incentives such as Payment for Environmental Services (see Sánchez-Azofeifa, et al., 2005). Priority should also be given to assessing the conservation priority of similar areas elsewhere in southern Mexico.

There is strong potential in coastal Oaxaca for CTU to contribute both to the conservation of globally important tree species diversity and local people's livelihoods through the following specific actions:

- Participatory initiatives to raise awareness among rural communities of the products and services provided by their forests and the options available for conservation through use.
- Participatory initiatives to develop and strengthen community-based structures for decision-making and regulation in relation to tree and forest use.
- Promotion of policies which value and support community-based structures for land management and decision-making, for example in the areas of agricultural incentives, land tenure and regulation.
- Research and promotion of strategies for increasing the biodiversity-friendly income-generating potential of community-based natural resource management, including the identification of efficient production technologies and marketing institutions, and the development of a supportive policy framework.
- Participatory development of mechanisms for the payment for environmental, recreational and other services from forests, and for the effective distribution of the resulting benefits to the people involved in, or affected by, forest conservation.
- Policy and regulatory support to the development of mechanisms for the payment for environmental services.

These recommendations are likely to be replicable wherever areas of vegetation of high global conservation importance persist, and where effective community organisation in favour of resource management and use exists. These conditions, particularly with regard to community-based management, are highly specific to Mexico, because of the particular cultural and legislative context found there (although, as seen in the communities of El Sanjón and El Limón in Oaxaca, there is also variation within Mexico with regard to the effectiveness of community organisation). In particular, similar conditions of extensive areas of apparently intact forest under similar conditions of community-based management may be found in the southern and western Mexico states of Guerrero, Michoacán and Jalisco, to the west of Oaxaca.

Future research priorities in relation to CTU in the MTDF

Case studies such as the ones presented in this book inevitably raise many new questions. Several priority areas for future research were identified:

- The local level work carried out in the course of this study in identifying species of global conservation concern (particularly those most susceptible to the effects of fragmentation and forest conversion) and the sites where they are found, needs to be repeated elsewhere in the region to increase the evidence base for conservation decisions.

- The objective approach presented here for assigning conservation priorities should be applicable to other life forms (with modifications, where necessary, to the methodology and criteria used for assessing priorities) and it would therefore be useful to develop a methodology for prioritising sites on the basis of the combined 'bioquality' indices of the different life forms which they contain.
- Future research could usefully aim to distinguish between cases where conservation is required at the level of whole landscapes, land use systems or vegetation types, and cases where it should focus on the conservation of individual species within the landscape.
- It is important to monitor the implications for the conservation status of dry forest, of changes in laws and policies in Mexico relating to communal tenure and community-based natural resource management.
- The hydrological and carbon storage benefits resulting from non-forest land management systems which allow the survival of large amounts of live tree material (including live stumps) need to be studied, in order to determine appropriate levels and types of support, including possible compensation to farmers for the provision of such benefits.
- Further work is needed with farmers to determine which global conservation priority species are of local value, in order to help identify opportunities for CTU.
- Finally, a more in-depth understanding of the costs and benefits to farmers of different tree and forest management practices could underpin programmes to support the maintenance or introduction of biodiversity-friendly land use amongst farmers.

Concluding remarks

In this book we have shown, based on case studies in MTDF landscapes of Oaxaca and Honduras, that CTU can under certain circumstances be effective for the conservation of globally-rare tree and shrub biodiversity (as in the case of the forests and mature fallows of coastal Oaxaca), and of the natural tree and shrub resources on which local people's livelihoods depend (as in the case of southern Honduras). We conclude the book with a number of caveats, however:

- Care should be taken to avoid assuming that synergies will naturally emerge between rural poverty reduction and the conservation of renewable natural resources, which is the 'win-win' situation hoped for under CTU (Barrett et al., 2005). MTDF landscapes are never static and even currently well conserved areas may come under threat in the future, for example from changing land use practices if *ejido* land is parcelled off or if there are major changes in agricultural commodity prices or demography. Constant monitoring is therefore required to ensure the utility and sustainability of CTU practices, backed up by support where necessary to facilitate adaptation to changing circumstances.
- We must also be aware of the complexity that underlies the seemingly simple term 'win-win'. In reality both rural development and conservation have multiple stakeholders with differing interests. It is most unlikely that all such stakeholders can be out-right winners. A win-win scenario is better envisaged as one in which conservation and rural

development goals are set by broad consensus, and trade-offs may be necessary to achieve them.

- Our research shows that the capacity of many dry forest species (albeit mainly those of lesser conservation concern) to persist in large numbers in highly disturbed agroecosystems, such as those of southern Honduras, should not be underestimated. To do so, and thereby to overstate the level of threat faced by such species, could lead to the misdirection of limited conservation resources toward species that are not under significant threat (Boshier et al., 2004) and the possible imposition of unnecessary restrictions on the productive activities of local people. The Rapid Botanical Survey method used in this study provides a useful and objective tool for identifying where the global priorities for conservation truly lie.
- Decisions on conservation priorities and strategies elsewhere in the MTDF need to be taken on a case-by-case basis, and in an informed and objective manner, based on systematic inventories of the numbers of high conservation species which they contain and investigations into productive, organisational, economic and tenure conditions. Assessments of conservation priorities and the development of conservation strategies should be integrated with socio-economic survey work and with the development of rural development strategies, in order to minimise the risk of conservation having negative effects on local people's livelihoods. The outcomes of these botanical and socio-economic surveys can determine the conservation approach used, including more conventional approaches such as protected areas and *ex situ* conservation, but also exploring the many opportunities offered by conservation through use.
- As we showed in Chapter 7, CTU can only be depended on as a conservation strategy if certain conditions are met. When they are not, as for example with globally-important species that are not valued by local people or do not prosper in disturbed environments, or when favourable conditions of tenure and community organization do not exist, 'backstopping' strategies such as *ex situ* conservation or the establishment of protected areas may still be needed.

References

Alix-Garcia, de Janvry, A. and Sadoulet, E. 2005. A tale of two communities: explaining deforestation in Mexico. *World Development* 33(2), 219-235.

Altieri, M.A. 1999. The ecological role of biodiversity in agroecosystems. *Agriculture, Ecosystems and Environment* 74(1-3), 19-31.

Altieri, M.A. and Merrick, L.C. 1987. *In situ* conservation of crop genetic resources through maintenance of traditional farming systems. *Economic Botany* 41, 86-96.

Barkin, D. and Paillés, C. 1998. Water as an instrument for sustainable regional development. *Conflict Resolution and Transboundary Water Resources*. No. 44, Fall/Winter 1998.

Barrance, A.J. 1997. Reconciling genetic conservation and local needs in the dry zone of Central America. *Commonwealth Forestry Review* 76(2), 98-102.

Barrance, A.J. 2000. A demand study of the priority researchable constraints for four groups of forest-dependent poor people in the management of forest and tree resources in Central America. DFID Forest Research Programme/Natural Resources International Limited. http://www.frp.uk.com/dissemination_documents/ZF0143_-_report_-_Revised.pdf

Barrance, A.J. and Hellin, J.J. 2003. Factores claves para el éxito de programas de reforestación y regeneración natural. In: *Árboles de Centroamérica – un Manual para Extensionistas*. OFI/CATIE/FRP.

Barrance, A.J., Flores, L., Padilla, E., Gordon, J.E. and Schreckenberg, K. 2003. Trees and farming in the dry zone of southern Honduras I: *campesino* tree husbandry practices. *Agroforestry Systems* 59, 97-106.

Barrance, A., Gordon, J. and Schreckenberg, K. 2006. Trends, cycles and entry points in the dry forest landscapes of Southern Honduras and Coastal Oaxaca. pp 53-76 in: Mistry, J. and Berardi, A. (eds). *Savannas and Dry Forests. Linking People with Nature*. Ashgate Publishing, Abingdon.

Belcher, B. and Schreckenberg, K. 2007. Commercialisation of non-timber forest products – A reality check. *Development Policy Review* 25(3), 355-377.

Benítez Ramos, R.F., Barrance, A.J. and Stewart, H. 2005. Have the Lessons of Mitch been forgotten?: The Critical Role of Sustainable Natural Resource Management for Poverty Reduction in Honduras. Study initiated under the Poverty and Environment Partnership (PEP), and jointly funded and managed by CIDA, DFID and GTZ.

Berrío, J.C., Hooghiemstra, H., van Geel, B., and Ludlow-Wiechers, B. 2006. Environmental history of the dry forest biome of Guerrero, Mexico, and human impact during the last c. 2700 years. *Holocene* 16, 63-80.

BirdLife International. 2003. *BirdLife's online World Bird Database: the site for bird conservation*. Version 2.0. BirdLife International, Cambridge, UK. Available: http://www.birdlife.org (accessed 15/4/2004)

Boshier, D.H. and Lamb, A.T. 1997. Cordia alliodora*: Genetics and Tree Improvement*. Tropical Forestry Paper 36, Oxford Forestry Institute, Oxford.

Boshier, D.H., Gordon, J.E., Barrance, A.J. 2004. Prospects for circa situm tree conservation in Mesoamerican dry forest agro-ecosystems. In: Frankie, G.W., Mata, A., Vinson, S.B. (eds). *Biodiversity Conservation in Costa Rica, Learning the Lessons in the Seasonal Dry Forest*. University of California Press, Berkeley.

Bray, D., Merino-Pérez, L. and Barry, D. 2005. Community managed in the strong sense of the phrase: The community forest enterprises of Mexico. In: Bray, D., Merino-Pérez, L. and Barry, D. (eds). *The Community Forests of Mexico. Managing for Sustainable Landscapes*, 3-26. University of Texas Press, Austin.

Brockington, D. and Schmidt-Soltau, K. 2004. The social and environmental impacts of wilderness and development. *Oryx* 38, 140-142 Cambridge University Press, Cambridge.

Brown, K. 2002. Innovations for conservation and development. *The Geographical Journal* 168(1), 6-17.

Bullock, S., Mooney, H. and Medina, E. (eds). 1995. *Seasonally Dry Tropical Forests*. Cambridge University Press, Cambridge, U.K.

Campos Arce, J.J., Villalobos, R. and Louman, B. 2005. Poor farmers and fragmented forests in Central America. In: Sayer, J.A. and Maginnis, S. (eds). *Forests in Landscapes. Ecosystem Approaches to Sustainability*, 129-146. Earthscan, London.

Castillo, A., Magaña, A., Pujadas, A., Martínez, L., and Godínez, C. 2005. Understanding the interaction of rural people with ecosystems: A case study in a Tropical Dry Forest of Mexico. *Ecosystems* 8, 630-643.

Ceballos, G. and García, A. 1995. Conserving neotropical biodiversity: the role of dry forests in Western Mexico. *Conservation Biology* 9(6), 1349-1353.

Chenier, J. 1995. Analysis of the interactions among four rural development organizations in southern Honduras. Project Paper, Cornell University.

Clercx, L. and Deugd, M. 2003. Pobreza, Agricultura Sostenible y Servicios Financieros Rurales en América Latina. Reflexiones sobre un estudio de caso en el Departamento de Lempira, Honduras. ICCO/CDR-ULA, San José, Costa Rica.

CONSEFORH. 1998a. Cedro espino (*Bombacopsis quinata* (Jacq.) Dugand): un árbol maderable con mercado potencial. CONSEFORH/AFE-COHDEFOR.

CONSEFORH. 1998b. Sipia (*Leucaena salvadorensis* de la familia *Leguminosae*): un árbol de uso múltiple. CONSEFORH/AFE-COHDEFOR.

Cooper, D., Vellve, R. and Hobbelink, H. (eds). 1992. Growing Diversity: Genetic Resources and Local Food Security. Intermediate Technology Publications, London.

Current, D., Lutz, E. and Scherr, S.J. (eds). 1995. Costs, benefits and farmer adoption of agroforestry: project experience in Central America and the Caribbean. World Bank Environment Paper 14, the World Bank, Washington DC.

Davies, J., Escalona Luttig, I. and Ortiz Blas, T. 2000. Aspectos económicos que influyen sobre la conservación de la diversidad de especies arbóreas en la selva baja de Oaxaca. Internal report, CUBOS Project, Overseas Development Institute, London.

Del Amo, S. 1992a. Problems of forest conservation: a feasible mechanism for biodiversity conservation. In: Steen, H.K. and Tucker, R.P. (eds). *Changing Tropical Forests: Historical Perspectives on Today's Challenges in Central and South America*, 21-27. Forest History Society, USA.

Del Amo, S. 1992b. Red de conservación de germoplasma en sistemas tradicionales: un mecanismo factible para el mantenamiento de la biodiversidad. In: Del Amo, S. (ed.) *Etnotécnicas*, 73-94. UNAM, SEDUE, SEP, Mexico D.F., Mexico.

DeWalt, B.R. 1983. The cattle are eating the forest. *Bulletin of the Atomic Scientists* 39(1),18-23.

DGECH. 1993. Censo Nacional Agropecuario, 1993. Dirección General de Estadísticas y Censos, Tegucigalpa, Honduras

Díaz Arrivillaga, E. 2000. Análisis del marco de políticas legal e institucional para la conservación de los recursos naturales de Honduras. Internal report, CUBOS Project, Overseas Development Institute, London.

Durán-Medina, E., Mas, J-F. and Velázquez, A. 2005. Land use/cover change in community-based forest management: regions and protected areas in Mexico. In: Bray, D., Merino-Pérez, L. and Barry, D. (eds). *The Community Forests of Mexico. Managing for Sustainable Landscapes*, 215-238. University of Texas Press, Austin.

Falcy, M.R. and Estades, C.F. 2007. Effectiveness of corridors relative to enlargement of habitat patches. *Conservation Biology* 21(5), 1341-1346.

Freese, C.H. 1997. The 'use it or lose it' debate: issues of a conservation paradox. In: Freese, C.H. (ed.) *Harvesting Wild Species: Implications for Biodiversity Conservation*, 1-47. Johns Hopkins University Press, Baltimore.

Geilfus, F. 2000. *Estrategias campesinas. Marco de análisis para el desarrollo rural*. IICA, Honduras.

Ghimire, K.B. and Pimbert, M.P. (eds). 1997. *Social Change and Conservation: Environmental Politics and Impacts of National Parks and Protected Areas*. Earthscan, London.

Gibson, C.C., Williams, J.T. and Ostrom, E. 2005. Local enforcement and better forests. *World Development* 33(2), 273-284.

Gillespie, T.W. and Walter, H. 2001. Distribution of bird species richness at a regional scale in tropical dry forest of Central America. *Journal of Biogeography* 28, 651-662.

González, A. and Beltrán, E. 2000. Contexto de políticas e instituciones para el desarrollo y la implementación de estrategias para el manejo y la conservación de la diversidad de especies arbóreas en la zona seca de la costa de Oaxaca. Grupo Mesófilo A.C., Oaxaca. Internal report, CUBOS Project, Overseas Development Institute, London.

Gordon, J.E. 2006. The role of science in NGO mediated conservation: insights from a biodiversity hotspot in Mexico. *Environmental Science and Policy* 9, 547-554.

Gordon, J.E. and Newton, A.C. 2006a. Efficient floristic inventory for the assessment of tropical tree diversity: A comparative test of four alternative approaches. *Forest Ecology and Management* 237, 564-573.

Gordon, J.E. and Newton, A.C., 2006b. The potential misapplication of rapid plant diversity assessment in tropical conservation. *Journal for Nature Conservation*. 14, 117–126.

Gordon, J.E., Bowen-Jones, E. and González, M.A. 2006. What determines dry forest conservation in Mesoamerica? Opportunism and pragmatism in Nicaraguan and Mexican preotected areas. In: Pennington RT, Lewis GP, and Ratter JA (eds). *Neotropical Savannas and Seasonally Dry Tropical Forest*s, 343-357. Taylor Francis, London.

Gordon, J.E., González, M.A., Vázquez Hernández, J., Ortega Lavariega, R. and Reyes-García, A. 2005. *Guaiacum coulteri*: an over-logged dry forest tree of Oaxaca, Mexico. *Oryx* 39, 82-85.

Gordon, J.E., Hawthorne, W., Reyes-García, A., Sandoval, G. and Barrance, A.J. 2004. Assessing Landscapes: a case study of tree and shrub diversity in the seasonally dry tropical forests of Oaxaca, Mexico and southern Honduras. *Biological Conservation* 117, 429-442.

Gordon, J.E., Hawthorne, W., Sandoval, G. and Barrance, A.J. 2003. Trees and farming in the dry zone of southern Honduras II – the potential for tree diversity conservation. *Agroforestry Systems* 59(2), 107-120.

Goulda, K., Howard, A.F. and Rodriguez, G. 1998. Sustainable production of non-timber forest products: Natural dye extraction from El Cruce Dos Aguadas, Petén, Guatemala. *Forest Ecology and Management* 111, 69-82.

Hamilton, A. and Hamilton, P. 2006. *Plant Conservation. An Ecosystem Approach*. Earthscan, London.

Hawthorne, W.D. and Abu-Juam, M. 1995. *Forest Protection in Ghana*. IUCN, Gland Switzerland and Cambridge, UK.

Hayes, T.M. 2006. Parks, people and forest protection: an institutional assessment of the effectiveness of protected areas. *World Development* 34, 2064-2075.

Hellin, J. and Hughes, C. 1993. *Leucaena salvadorensis*. Conservation and utilization in Central America. Serie Miscelánea de CONSEFORH No. 39-21/93. COHDEFOR-ODA-ESNACIFOR, Siguatepeque, Honduras.

Hobley, M. 2006. *Where in the World is there Pro-poor Forestry Policy and Tenure Reform?* Rights and Resources Initiative, Washington DC.

Holdridge, L.R., Grenke, W.C., Hatheway, W.H., Liang, T. and Tosi, J.A. 1971. *Forest Environments in Tropical Life Zones, A Pilot Study*. Pergamon Press, New York.

Holland, J. and Campbell, J. 2005. Context and challenges for combining methods in development research. In: Holland, J. and Campbell, J. (eds). *Methods in Development Research: Combining Quantitative and Qualitative Approaches*, 1-18. ITDG Publishing, London.

Hughes, C.E. 1998. Leucaena: *a Genetic Resource Manual*. Tropical Forestry Paper 37, Oxford Forestry Institute. Oxford, UK.

Hutton, J.M. and Leader-Williams, N. 2003. Sustainable use and incentive-driven conservation: realigning human and conservation interests. *Oryx* 37(2), 215-226.

IUCN. 1994. IUCN Red List Categories. IUCN Species Survival Commission. The World Conservation Union.

Jansen, H.G.P., Rodriguez, A., Damon, A., Pender, J., Chenier, J. and Schipper, R. 2006. Determinants of income-earning strategies and adoption of conservation practices in hillside communities in rural Honduras. *Agricultural Systems* 88, 92-110.

Janzen, D.H. 1986. *Guanacaste National Park: Tropical Ecological and Cultural Restoration*. Editorial Universidad Estatal a Distancia, San José, Costa Rica.

Janzen, D.H. 1988. Tropical dry forests – the most endangered major tropical ecosystem. In: Wilson, E.O. (ed.) *Biodiversity*. National Academy Press, Washington DC.

Janzen, D.H. and Liesner, R. 1980. Annotated checklist of plants of lowland Guanacaste Province, Costa Rica, exclusive of grasses and non-vascular cryptograms. *Brenesia* 18, 15-90.

MacQueen, D., Barrance, A.J. and Holt, G. 2001. Common problems and priority research and development themes for the forest-dependent poor. *International Forestry Review* 3(2), 105-120.

Margules, C. and Pressey, R. 2000. Systematic conservation planning. *Nature* 405, 243-253.

Maass, J.M. 1995. Conversion of tropical dry forest to pasture and agriculture. In: Bullock, S.H., Mooney, H.A. and Medina, E. (eds.) *Seasonally Dry Topical Forests*, 399-418. Cambridge University Press, Cambridge.

Méndez, V.E., Gliessman, S.R. and Gilbert, G.S. 2007. Tree biodiversity in farmer cooperatives of a shade coffee landscape in western El Salvador. *Agriculture, Ecosystems and Environment* 119, 145-159.

Menzies, N.K. 2007. *Our Forest, Your Ecosystem, Their Timber. Communities, Conservation, and the State in Community-Based Forest Management*. Columbia University Press, New York.

Middleton, B.A., Sanchez-Rojas, E., Suedmeyer, B., and Michels, A. 1997. Fire in a tropical dry forest of Central America: a natural part of the disturbance regime? *Biotropica* 29, 515-517.

Miles, L., Newton, A.C., DeFries, R., Ravilious, C., May, I., Blyth, S., Kapos, V. and Gordon, J.E. 2006. A global overview of the conservation status of tropical dry forests. *Journal of Biogeography* 33, 491-505.

Miller, K., Chang, E and Johnson, N. 2001. *Defining common ground for the Mesoamerican Biological Corridor.* World Resources Institute, Washington DC.

Murphree, M. 2003. Control and the Holy Grail. In: Oldfield, S. (ed.) *The Trade in Wildlife: Regulation for Conservation*, 52-60. Earthscan, London.

Murphy, P.G. and Lugo, A.E. 1986. Ecology of tropical dry forest. *Annual Review of Ecology and Systematics* 17, 67-88.

Murphy, P.G. and Lugo, A.E. 1995. Dry forests of Central America and the Caribbean. In: Bullock, S.H., Mooney, H.A. and Medina, E. (eds.) *Seasonally Dry Topical Forests*, 9-29. Cambridge University Press, Cambridge.

Nepstad, D. and Schwartzman, S. 1992. Non-timber forest products from tropical forests. Evaluation a conservation and development strategy. *Advances in Economic Botany* 9. The New York Botanical Garden, New York.

Newson, L. 1992. *El Costo de la Conquista*. Editorial Guaymuras, Tegucigalpa, Honduras.

Olson, D.M., Dinerstein, E., Wikramanayake, E.D., Burgess, N.D., Powell, G.V.N., Underwood, E.C., D'amico, J.A., Itoua, I., Strand, H.E., Morrison, J.C., Loucks, C.J., Allnutt, T.F., Ricketts, T.H., Kura, Y., Lamoreux, J.F., Wettengel, W.W., Hedao, P. and Kassem, K. 2001. Terrestrial Ecoregions of the World: A New Map of Life on Earth. *BioScience* 51(11), 933-938.

Otterstrom, S.M. and Schwartz, M.W. 2006. Responses to fire in selected tropical dry forest trees. *Biotropica* 36, 592-598.

Pimental, D., Stachow, U., Takacs, D.A., Brubaker, H.W., Dumas, A.R., Meany, J.J., O'Neal, J.A.S., Onsi, D.E. and Cozilius, D.B. 1992. Conserving biological diversity in agricultural and forestry systems. *BioScience* 42, 354-362.

Pretty, J.N., Guijt, I., Thompson, J. and Scoones, I. 1995. *A Trainer's Guide for Participatory Learning and Action*. IIED Participatory Methodology Series, IIED, London.

Redford, K.H. and Richter, B.D. 1999. Conservation of Biodiversity in a World of Use. *Conservation Biology* 13, 1246.

Republic of Honduras. 2001. Poverty Reduction Strategy Paper 2001-2005.

Reyes-García, A. and Sousa S. M. 1997. *Depresión Central de Chiapas: La Selva Baja Caducifolia*. Mexico City, UNAM.

Richards, M., Rodríguez, A., García, A. and Zuleta, M. 2000. Análisis económico de árboles en explotaciones agrícolas en el sur de Honduras. Internal report, CUBOS Project, Overseas Development Institute, London.

Robinson, J.G. and Redford, K.H. 2004. Jack of all trades, masters of none: Inherent contradictions among ICD approaches. In: McShane, T.O. and Wells, M.P. (eds). *Getting Biodiversity to Work. Towards More Effective Conservation and Development*, 10-34. Columbia University Press, New York.

Rodríguez Canto, A. 1995. *Historia Agrícola y Agraria de la Costa Oaxaqueña*. Universidad Autónoma Chapingo.

Ruiz Pérez, M. and Arnold, J.E.M. (eds).1996. *Current Issues in Non-timber Forest Products Research*. Center for International Forestry Research, Bogor.

Sánchez-Azofeifa, G.A., Kalacska, M., Quesada, M., Calvo-Avarado, J.C., Nassar, J.M. and Rodríguez, J.P. 2005. Need for integrated research for a sustainable future in tropical dry forests. *Conservation Biology* 19(2), 285-286.

Sayer, J., Maginnis, S. and Laurie, M., (eds). 2005. *Forests in landscapes: ecosystem approaches to sustainability* IUCN, Forest Conservation Programme, Earthscan, London.

Schelhas, J., Buck, L.E. and Geisler, C.C. 2001. Introduction: the challenge of adaptive collaborative management. In: Buck, L.E., Geisler, C.C., Schelhas, J. and Wollenberg, E. (eds). *Biological Diversity: Balancing Interests through Adaptive Collaborative Management*, xix-xxxv. CRC Press, Boca Raton.

Schreckenberg, K. and Bird, N. 2006. Developmental impacts of verification systems in the forest sector. VERIFOR Briefing Paper 3. ODI, London.

Schreckenberg, K., Barrance, A., Degrande, A., Gordon, J., Leakey, R., Marshall, E., Newton, A. and Tchoundjeu, Z. 2005. Trade-offs between management costs and research benefits: Lessons from the forest and the farm. In: Holland, J. and Campbell, J. (eds). *Methods in Development Research: Combining Quantitative and Qualitative Approaches*, 191-204. ITDG Publishing, London.

Schreckenberg, K., Lawrence, A., Mackenzie, C., Bryden, J., Luttrell, C. and O'Connor, H. 2002. Startegic researchable constraints for participatory forest management. Research report. ODI, London.

Sekhran, N. 1996. Pursuing the 'D' in Integrated Conservation and Development Projects (ICADPs): Issues and Challenges for Papua New Guinea. Rural Development Forestry Network Newsletter 19b, Overseas Development Institute, London.

Stewart, J.L., Allison, G.E. and Simons, A.J. (eds). 1996. Gliricidia sepium: *Genetic resources for farmers*. Tropical Forestry Papers. Oxford Forestry Institute, Oxford.

Stonich, S. 1993. *I Am Destroying the Land: The Political Ecology of Poverty and Environmental Destruction in Honduras*. Westview Press, Boulder.

Suazo, J., Walter, I., Ramos, M. and Zelaya, S. 1997. Políticas forestales en Honduras: Análisis de las restricciones para el desarrollo forestal. In: Segura, O. and Kaimowitz, D. (eds) *Políticas forestales en Centro América*. IICA, PFA, CCAB-AP.

Terborgh, J.W., van Schaik, C., Davenport, L., and Rao, M. (eds). 2002. *Making Parks Work: Strategies for Preserving Tropical Nature.* Island Press, Washington DC

Toledo, V.M., Carabias, J., Toledo, C. and González-Pacheco, C. 1989. *La producción rural en México: alternativas ecológicas*. Fundación Universo XXI, Mexico, D.F.

Trejo, I. and Dirzo, R. 2000. Deforestation of seasonally dry tropical forest: a national and local analysis in Mexico. *Biological Conservation* 94(2), 133-142.

UNDP. 2006a. Human Development Indicators 2004 (Honduras). Available at: http://www.undp.un.hn/INDH2006/descargas/indicadores.pdf (accessed 15/10/2007)

UNDP. 2006b. Informe sobre Desarrollo Humano Mexico 2006-7. Available at: http://saul.nueve.com.mx/estadisticas/index.html (accessed 15/10/2007).

Utting, P. 1993. *Trees, People and Power: Social Dimensions of Deforestation and Forest Protection in Central America*. Earthscan Publications, London.

Vandermeer, J. and Perfecto, I. 1997. The agro-ecosystem: a need for the conservation biologist's lens. *Conservation Biology* 11, 591-2.

van Schaik, C. and Rijksen, H.D. 2002. Integrated conservation and development projects: problems and potential. In: Terborgh, J.W., van Schaik, C., Davenport, L. and Rao, M. (eds). *Making Parks Work: Strategies for Preserving Tropical Nature*. Island Press, Washington D.C.

Velásquez Zepeda, M.C. 1998 Territorialidad Jurídica en 12 Zonas de Conservación del Estado de Oaxaca (México). WWF/CODE, Oaxaca.

Wells, M. and Brandon, K. 1992. *People and Parks: Linking Protected Area Management with Local Communities*. World Bank/WWF/USAID, Washington, DC.

White, G.M. and Boshier, D.H. 2000. Fragmentation in Central American dry forests – genetic impacts on *Swietenia humilis*. In: Young, A.G. and Clarke, G. (eds), *Genetics, demography and the viability of fragmented population*, 293-311. Cambridge University Press, Cambridge.

Whittaker, R.J. 1998. *Island Biogeography: Ecology, Evolution and Conservation*. Oxford University Press, Oxford.

Wolbers, K. 1998. Heeding the Lessons Learnt: A Comparative Analysis of Two ICAD Projects in Papua New Guinea. Available at: http://www.protected-landscapes.org/AbstractsTZ.html (accessed 1/2/05).

Wollenberg, E. and Ingles, A. (eds). 1998. *Incomes from the Forest. Methods for the development and conservation of forest products for local communities*. CIFOR and IUCN, Bogor.

WCMC. 2004. Habitats/Forest/Regional information/Central America. Available at: http://www.unep-wcmc.org/index.html?http://www.unep-wcmc.org/cis/~main (accessed 19/1/2004)

WWF. 2004. Global 200 – Blueprint for a living planet. Ecoregion 56: Neotropical Mexican Dry Forest. Available: http://www.panda.org/about_wwf/where_we_work/ecoregions/global200/pages/regions/region056.htm (accessed 19/1/2004)

Appendix 1. Comparing the conservation importance of different sites using the 'genetic heat index'

In Chapter 6 it was explained how different species were assigned discrete categories according to their priority for conservation. The criteria used in this study for this classification are presented in Table 3.3. However this species level classification is not alone sufficient to enable us to make direct comparisons between sites in terms of their conservation importance. How for example, can we decide whether a site that contains two species defined as being of Category B is of greater or lesser priority than one that contains a single Category A species? To achieve this, we need a form of weighting that provides us with a site-level index.

The method used in this study to address this has been developed from one first devised in Ghana by Hawthorne and Abu-Juam (1995)

The starting point in this method is for each category (here A, B, C or D) to be given a weighting or value that reflects its degree of conservation concern. This can then be used as the basis to calculate a numeric score (the GHI) for the entire site-level sample.

This is done in the following steps (see Table A.1 below):

1. Firstly, the area of occupancy of species in each category is estimated from distribution maps in botanical monographs by simply counting the number of degree squares occupied by each species. For the majority of species such maps are not available, so the average calculated for those that do is used for the rest.
2. Secondly, the ratios of the average areas of occupancy of each category is calculated by dividing each by the areas of occupancy of category D. Thus category D temporarily gets a score of 1.
3. These ratios are then inverted to give Category A the highest score, and each is rounded to the nearest integer.
4. Then, the Category D score is arbitrarily converted to zero, on the basis that species in this category are not of conservation concern and should not affect the index.
5. Genetic Heat Indices (GHI) are then calculated, based on these weightings, according to the following formula (where N is the total number of identified species in a sample):

$$GHI = \frac{[(\text{No Cat A spp x 32}) + (\text{No of Cat B spp x 12}) + (\text{No of Cat C spp x 5})] \times 100}{N}$$

Table A.1. Calculation of weightings for conservation categories

	A	B	C	D
1. Mean area of occupancy (No degree squares: n)	1.67	4.5	10.33	53.68
2. n/53.68 (=x)	0.031	0.084	0.192	1
3. 1/x	32.14	11.93	5.19	1
4. Rounded weighting	32	12	5	0

Two points should be made here. The weightings calculated as shown in Table A.1 are not universal: application of this methodology to different projects working in different regions will result in the calculated weighting for each category being different. This is due to differences in the patterns of distribution of each species and the differences in the sizes of the geographical units (in this case states/countries) used for the initial delimitation of each of the categories (see table 7.2). However, once the weightings of categories are recalibrated for a different set of species in a different geographical region, the resulting GHIs could be compared with those given here.

Secondly, because in the GHI formula the denominator, N, is all species in the sample, an 'average' results that allows comparison of samples with different numbers of species. Ideally N should be reasonably large (> 30) to ensure GHIs are not overly sensitive to the inclusion or loss of single Category A or B species. However, here a minimum of 15 species is used in the analysis to ensure reasonable representation of some of the agricultural samples of low species richness.

The GHIs calculated as explained above allowed direct comparisons to be made of samples taken from different land uses in different countries and with different species.

Appendix 2. Species of Conservation Concern Found in the Oaxaca Study Area

CATEGORY A (including possible new species):

Carlowrightia sp. nov. ACANTHACEAE
Achatocarpus oaxacanus Standl. ACHATOCARPACEAE Mature forest fragments, occasionally fallows.
Licania sp. nov CHRYSOBALANACEAE
Trixis silvatica B.L.Rob. & Greenm. COMPOSITAE Mature forest fragments.
Jatropha alamani Muell.Arg. EUPHORBIACEAE Mature forest fragments and fallows.
Jatropha sympetala Standl. & Blake EUPHORBIACEAE Mature forest fragments and fallows.
Jatropha sp. nov. EUPHORBIACEAE
Manihot oaxacana D.J.Rogers & Appan Black. EUPHORBIACEAE Mature forest fragments and fallows.
Caesalpinia coccinea G.P.Lewis & J.L.Contr. LEGUMINOSAE-CAESALPINIOIDEAE Forest fragments and edges.
Mimosa albida Humb. & Bonpl. ex Willd. var. *pochutlensis* R.Grether LEGUMINOSAE-MIMOSOIDEAE. Disturbed forest fragments.
Zapoteca tehuana H.M.Hern. LEGUMINOSAE-MIMOSOIDEAE Mature forest fragments.
Lonchocarpus sp. nov. LEGUMINOSAE-PAPILIONOIDEAE
Bunchosia discolor Turcz. ex Char. MALPIGHIACEAE Mature forest fragments.
Megastigma sp. nov. RUTACEAE
Thouinia (undescribed species) SAPINDACEAE
Castela retusa Liebm. SIMAROUBACEAE Mature forest fragments.
Waltheria conzatii Standl. STERCULIACEAE Fallow.

CATEGORY B:

Sapranthus foetidus (Rose) Saff. ANNONACEAE Jalisco, Guerrero & Oaxaca. Mature forest fragments and fallows.
Bourreria purpusii Brandgee BORAGINACEAE Jalisco & Oaxaca. Mature forest fragments.
Forchhammeria lanceolata Standl. CAPPARIDACEAE Oaxaca & Gurerro. Mature forest fragments and fallow.
Bucida wigginsiana Miranda COMBRETACEAE Guererro Oaxaca. Mature forest fragments.
Trixis pterocaulis B.L.Rob. & Greenm. COMPOSITAE Jalisco, Colima & Oaxaca. Mature semi-deciduous forest fragments.
Acalypha liebmannii (Muell.Arg.) Lundell EUPHORBIACEAE Oaxaca, Guerrero. Disturbed seasonal oak forest.
Caesalpinia hughesii G.P.Lewis LEGUMINOSAE-CAESALPINIOIDAE Oaxaca, Guererro & Colima. Forest fragments and edges.
Brongniartia bracteolata Micheli LEGUMINOSAE- PAPILIONOIDAE Oaxaca & Chiapas. Mature forest fragments, occasional fallows and farmland.
Lonchocarpus emarginatus Pittier LEGUMINOSAE-PAPILIONOIDAE Oaxaca & Chiapas. Mature forest fragments.
Lonchocarpus longipedicellatus Pittier LEGUMINOSAE-PAPILIONOIDAE Jalisco, Guererro & Oaxaca. Mature forest fragments.
Hibiscus kochii Fryxell MALVACEAE Guererro, Oaxaca. Mature forest fragments.
Eugenia salamensis Donn.Sm. var. *rensoniana* (Standl.) McVaugh MYRTACEAE Oaxaca Guatemala & Costa Rica. Mature forest fragments.

Guettarda galeottii Standl. RUBIACEAE Sinaloa, Nayarit & Oaxaca. Fallows.
Randia cinerea (Fernald) Standl. RUBIACEAE Oaxaca & Guererro. Fallows.
Recchia mexicana Moc. & Sessé SIMAROUBACEAE Oaxaca & Jalisco. Mature forest fragments, occasional fallows.
Physodium oaxacanum Dorr & Barnett STERCULIACEAE Oaxaca & Chiapas.
Triumfetta heliocarpoides Bullock TILIACEAE Guererro & Oaxaca. Seasonal oak forest.
Aloysia chiapensis Moldenke VERBENACEAE Oaxaca & Chiapas. Solar.

CATEGORY C:

Achatocarpus mexicanus H.Walter ACHATOCARPACEAE Chiapas & Oaxaca – not limited to Pacific dry forest. Mature forest fragments.
Lagrezia monosperma (Rose) Standl. AMARANTHACEAE Jalisco, Michoacan, Colima, Guererro & Oaxaca. Mature forest fragments.
Actinocheita filicina (DC.) F.A.Barkley ANACARDIACEAE Guererro, Oaxaca, Chiapas & Puebla – not limited to Pacific dry forest. Disturbed forests and farmland.
Bursera aptera Ramirez BURSERACEAE Guererro, Oaxaca, Puebla & Morelos – not limited to pacific dry forest. Mature forest fragments.
Bursera instabilis McVaugh & Rzed. BURSERACEAE Nayarit, Jalisco, Michoacan, Colima, Guererro & Oaxaca. Mature forest fragments.
Capparis angustifolia Kunth CAPPARIDACEAE Guererro & Oaxaca. Mature forest fragments.
Bucida macrostachya Standl. COMBRETACEAE Oaxaca, Chiapas, Belize, Guatemala, Honduras & Nicaragua. Mature forest fragments, occasional fallows.
Chromolaena glaberrima (DC.) R.M.King & H.Rob. COMPOSITAE Oaxaca – not limited to Pacific dry forest. Principally oak forest.
Montanoa tomentosa Cerv. ssp. *microcephala* (Sch.Bip.) V.A.Funk COMPOSITAE Oaxaca – not limited to Pacific dry forest. Principally seasonal oak forest.
Verbesina oaxacana DC. COMPOSITAE Oaxaca – not limited to Pacific dry forest. Fallows.
Croton axillaris Muell.Arg. EUPHORBIACEAE Oaxaca, Chiapas, San Luis Potosí, Tamaulipas, Guatemala Nicaragua Costa Rica. Mature forest fragments.
Croton ramillatus Croizat EUPHORBIACEAE Guererro Oaxaca Veracruz – not limited to Pacific dry forest. Mature forest fragments.
Croton septemnervius McVaugh EUPHORBIACEAE Jalisco Guererro Oaxaca – not limited to Pacific dry forest. Mature forest fragments and fallows.
Casearia williamsiana Sleumer FLACOURTIACEAE Honduras – not limited to Pacific dry forest. Disturbed forest fragments.
Samyda mexicana Rose FLACOURTIACEAE Jalisco, Guererro, Oaxaca, Veracruz – not limited to Pacific dry forest Mature forest fragments.
Gyrocarpus mocinnoi Espejo HERNANDIACEAE Guererro, Chiapas, Oaxaca, Puebla & Guatemala. Mature forest fragments and fallows.
Hyptis tomentosa Poit. LABIATAE Oaxaca, Chiapas, Veracruz – not limited to Pacific dry forest. Mature forest fragments, fallows and farmland.
Caesalpinia mollis (Kunth) Spreng. LEGUMINOSAE-CAESALPINIODEAE – not limited to Pacific dry forest.
Cynometra oaxacana Brandegee LEGUMINOSAE-CAESALPINIODEAE Jalisco, Colima, Guererro, Oaxaca & Chiapas. Mature forest fragments.

Calliandra hirsuta (G.Don) Benth. LEGUMINOSAE-MIMOSOIDAE Guererro, Oaxaca, Chiapas, Puebla – not limited to Pacific dry forest. Farm land.

Havardia campylacanthus (L.Rico & M.Sousa) Barneby & J.W.Grimes LEGUMINOSAE-MIMOSOIDAE Michoacan, Guererro, Oaxaca Belize, Nicaragua & Honduras. Forest fragments and farmland.

Mimosa eurycarpa B.L.Rob. LEGUMINOSAE-MIMOSOIDAE Michoacan, Colima, Oaxaca – not limited to Pacific dry forest. Mature forest fragments.

Mimosa robusta R.Grether LEGUMINOSAE-MIMOSOIDAE Farmland.

Indigofera platycarpa Rose LEGUMINOSAE-PAPILIONOIDAE Guererro Oaxaca Pue Mor – not limited to Pacific dry forest. Mature forest fragments.

Lonchocarpus constrictus Pittier LEGUMINOSAE-PAPILIONOIDAE Jalisco, Michoacan, Colima, Guererro & Oaxaca. Mature forest fragments and occasionally forests.

Platymiscium lasiocarpum Sandwith LEGUMINOSAE-PAPILIONOIDAE Jalisco Michoacan Guererro Oaxaca – not limited to Pacific dry forest. Mature forest fragments

Abutilon grandidentatum Fryxel. MALVACEAE Oaxaca, Chiapas – not limited to Pacific dry forest. Mature forest fragments.

Hibiscus peripteroides Fryxell MALVACEAE Oaxaca, San Luis Potosí – not limited to Pacific dry forest. Reverine forest.

Torrubia macrocarpa Miranda NYCTAGINACEAE Oaxaca Mature forest fragments, occasionally farmland.

Chiococca filipes Lundell RUBIACEAE Oaxaca, Chiapas & Honduras – not limited to Pacific dry forest. Seasonal oak forest.

Randia nelsonii Greenm. RUBIACEAE Sinaloa, Michoacan Oaxaca & Veracruz – not limited to Pacific dry forest. Mature forest fragments.

Rondeletia deamii (Donn.Sm) Standl. RUBIACEAE Oaxaca, Guatemala, Honduras & Nicargua – not limited to Pacific dry forest. Forest fragments and farmland.

Heliocarpus occidentalis Rose TILIACEAE Guererro & Oaxaca. Mature forest fragments.

Appendix 3. Species of conservation concern found in the Honduran study area

CATEGORY A:
None

CATEGORY B:
Leucaena salvadorensis Standl. LEGUMINOSAE-MIMOSOIDAE El Salvador, Nicaragua & Honduras. Disturbed forest fragments and farmland.

Eugenia hondurensis Ant. Molina MYRTACEAE Honduras & Nicaragua. Disturbed forests and farmland.

Grajalesia fasciculata (Standl.) Miranda NYCTAGINACEAE Guatemala ELS Honduras Nicaragua. Disturbed forest and farmland.

Guettarda deamii Standl. RUBIACEAE Guatemala, El Salvador, Honduras Nicaragua. Disturbed forest fragments.

CATEGORY C:
Persea caerulea (Ruiz & Pav.) Mez LAURACEAE El Salvador, Honduras Nicaragua Costa Rica & Panama. Disturbed forest fragments.

Casearia williamsiana Sleumer FLACOURTIACEAE Honduras, Nicaragua – not limited to Pacific dry forest. Disturbed forest fragments.

Mimosa panamensis (Benth.) Standl. LEGUMINOSAE-MIMOSOIDAE Honduras & Panama – not limited to Pacific dry forest Farmland.

Bunchosia guatemalensis Ndzu MALPIGHIACEAE Chiapas, Guatemala & Honduras – not limited to Pacific dry forest. Disturbed forest fragments.

Randia pleiomeris Standl. RUBIACEAE Guatemala, El Salvador & Honduras – not limited to Pacific dry forest. Disturbed forest fragments and farmland.

Rondeletia deamii (Donn.Sm) Standl. RUBIACEAE Oaxaca, Guatemala, Honduras & Nicaragua – not limited to Pacific dry forest. Forest fragments and farmland.

Trigonia rugosa Benth. TRIGONIACEAE Guatemala El Salvador, Honduras & Nicuargua – not limited to Pacific dry forest Disturbed forest fragments.

IUCN Categories:
Vulnerable
Bombacopsis quinata (Jacq.) Dugand. BOMBACACEAE Disturbed forest fragments, occasionally farmland.

Endangered
Guaiacum sanctum L. ZYGOPHYLLACEAE Disturbed forest fragments.

Appendix 4. Checklist of woody species for Oaxacan and Honduran Pacific Coast dry forests

A. Reyes-García, G. Sandoval, J. E. Gordon

The species listed were found during surveys of dry forest fragments and farmland in southern Honduras and southern Oaxaca, Mexico from 1998-2000. The definition of a woody species included any individual found unsupported with woody stem of at least 1cm diameter at ground level. Thus although lianas are not generally included, in some cases species known as lianas are listed because they were found in free-standing habit. Species known to be exotic are included and are marked with an asterisk. It includes species from samples from deciduous oak forest in Oaxaca, a forest type not usually considered dry forest. The familial and generic organisation of the list follows Mabberley (1997)* except where noted. Vouchers were deposited in the National Herbarium, Mexico City (MEXU) and the Paul C. Standley Herbarium, El Zamorano, Honduras (EAP).

Each species listed is preceded by H, O or H O depending upon whether it was found in Honduras, Oaxaca or both, respectively. Species of conservation concern are in bold. The conservation status was either determined with reference to IUCN lists (Oldfield et al 1998) or by a modification of the Star system (Hawthorne 1996) described elsewhere in this volume. In the latter case the estimated distribution of Class B and Class C species, on which the ranking is based, is noted. This is not done for Class A which by definition are endemic to the dryforest areas of the area in which they were found. The habitat type in which these species were found is also noted.

The following abbreviations are used to describe distribution of species of conservation concern: PDF- Pacific dry forest. Sin- Sinaloa; Jal- Jalisco; Mich- Michoacan; Col- Colima; Nay- Nayarit; Gro- Guerrero; Oax- Oaxaca; Chis- Chiapas; SLP- San Luis Potosí; Mor- Morelos; Pue- Puebla; Tam- Tamaulipas; Ver- Veracruz; Yuc- Yucatán; Qroo- Quintana Roo; Bel- Belize; Guat- Guatemala; ELS- El Salvador; Hon- Honduras; Nic- Nicaragua; CR- Costa Rica; Pan- Panama.

The authors are grateful to the following for their help with identification of specimens: Antonio Molina (EAP), Jorge Araque (EAP), Ramón Zúniga (EAP), William Hawthorne (FHO), Mario Sousa (MEXU – Leguminosae), Hector Hernández (MEXU – *Zapoteca* & *Calliandra*), Cathrin Perret (SERBO – *Grajalesia*), Gabriel Flores (MEXU – *Senna*), Guillermo Ibarra (Instituto de Ecología, UNAM – *Ficus*), Jaime Jiménez (Fac. Ciencias, UNAM – *Jatropha*), Martha Martínez (Fac. Ciencias UNAM – Euphorbiaceae), M. Teresa Germán (MEXU – Meliaceae), Susana Valencia (Fac. Ciencias, UNAM – *Quercus*), Colin Pendry (RBGE – *Ruprechtia*).

* Mabberley, D.J. (1997). The Plant-Book (2nd edition). Cambridge, Cambridge University Press.

Acanthaceae

H *Aphelandra aurantiaca* (Scheidw.) Lindl.
H O *Aphelandra scabra* (Vahl) Sm.
O *Barleria micans* Nees
O *Justicia caudata* A.Gray
H *Odontonema callistachyum* (Schltdl. & Cham.) Kuntze[1]

Achatocarpaceae

O *Achatocarpus gracilis* H.Walter
O ***Achatocarpus mexicanus*** H.Walter
Category C (Chis Oax – not limited to PDF). Mature forest fragments.
O ***Achatocarpus oaxacanus*** Standl.
Category A. Mature forest fragments, occasionally fallows.

Amaranthaceae

O *Alternanthera pyncantha* (Benth.) Standl.
H O *Celosia argentea* L.
H *Celosia virgata* Jacq.
O *Iresine calea* (Ibáñez) Standl.
H O *Iresine diffusa* Willd.
O ***Lagrezia monosperma*** (Rose) Standl.
Category C (Jal Mich Col Gro Oax). Mature forest fragments.

Anacardiaceae

H ***Actinocheitia filicina*** (DC.) F.A.Barkley
Category C (Gro Oax Chis Pue – not limited to PDF). Disturbed forests and farmland.
O *Amphipterygium adstringens* (Schltdl.) Standl.
H *Anacardium excelsium* (Bert. & Balb.) Skeels
H O *Anacardium occidentale* L.
H O *Astronium graveolens* Jacq.
O *Comocladia engleriana* Loes.
H O **Mangifera indica* L.
O *Pseudosmodingium multifolium* Rose
H O *Spondias purpurea* L.

Annonaceae

O *Annona cherimola* Mill.
O *Annona diversifolia* Saff.
H O *Annona glabra* L.
H *Annona holosericea* Saff.
H O *Annona muricata* L.
H *Annona purpurea* L.
H O *Annona reticulata* L.
H O *Annona squamosa* L.
O ***Sapranthus foetidus*** (Rose) Saff.
Category B (Jal Gro Oax). Mature forest fragments and fallows.
H O *Sapranthus microcarpus* (Donn.Sm.) R.E.Fries
H *Sapranthus violaceus* (Dunal) Saff.

Apocynaceae

H O *Plumeria rubra* L.
O *Rauvolfia ligustrina* Roem. & Schult.
H O *Rauvolfia tetraphylla* L.
H O *Stemmadenia obovata* (Hook. & Arn.) K.Schum.
O *Tabernaemontana amygdalifolia* Jacq.
O *Tabernaemontana divaricata* R.Br. ex Roem. & Schult.
H *Thevetia gaumeri* Hemsl.
H O *Thevetia ovata* (Cav.) A.DC.
H O *Thevetia peruviana* (Pers.) K.Schum.
O *Thevetia thevetioides* (Kunth) K.Schum.

Araliaceae

H O *Dendropanax arboreum* (L.) Decne. & Planch.
H *Sciadodendron excelsum* Griseb.

Asclepiadaceae

H **Calotropsis procera* (Aiton) Aiton f.
H **Cryptostegia madagascariensis* Bojer & Decne.
H *Matelea prosthecidiscus* Woodson

Bignoniaceae

O *Astianthus viminalis* (Kunth) Baill.
H *Crescentia alata* Kunth
H O *Crescentia cujete* L.
H O *Godmania aesculifolia* (Kunth) Standl.
H **Jacaranda mimosaefolia* D.Don.
H *Lundia puberula* Pittier
O *Parmentiera aculeata* (Kunth) Seem.

H O *Spathodea campanulata* Beauv.
O *Tabebuia impetiginosa* (Mart. ex DC.) Standl.
H O *Tabebuia ochracea* (Cham.) Standl. ssp. *neochrysantha* (A. Gentry) A. Gentry
H O *Tabebuia rosea* (Bertol.) DC.
H O *Tecoma stans* (L) Juss. ex Kunth

Bixaceae

H O *Bixa orellana* L.
H O *Cochlospermun vitifolium* (Willd.) Spreng.

Bombacaceae

H ***Bombacopsis quinata*** (Jacq.) Dugand. [= Pachira quinata (Jacq.) W. S. Alverson Vulnerable. Disturbed forest fragments, occasionally farmland.
H O *Ceiba aesculifolia* (Kunth) Britton & Baker f.
O *Ceiba parvifolia* Rose
H O *Ceiba pentandra* (L.) Gaertn.
O *Pseudobombax ellipticum* (Kunth) Dugand

Boraginaceae

O ***Bourreria purpusii*** Brandgee Category B (Jal Oax). Mature forest fragments.
H O *Cordia alliodora* (Ruiz & Pav.) Oken
H *Cordia collococca* L.
H O *Cordia curassavica* (Jacq.) Roem. & Schult.
H O *Cordia dentata* Poir
O *Cordia elaeagnoides* A.DC.
H *Cordia gerascanthus* L.
O *Cordia globosa* (Jacq.) Kunth
H *Cordia inermis* (Mill.) I.M.Johnst.
H *Cordia nitida* Vahl
O *Cordia seleriana* Fernald
O *Tournefortia hirsutissima* L.

Buddlejaceae

H O *Buddleja americana* L.

Burseraceae

O ***Bursera aptera*** Ramirez Category C (Gro Oax Pue Mor – not limited to PDF). Mature forest fragments.
O *Bursera arborea* (Rose) L.Riley
O *Bursera bipinnata* (Sessé & Moc. ex DC.) Engl.
O *Bursera copallifera* (Sessé & Moc. ex DC.) Bullock
O *Bursera excelsa* (Kunth) Engl.
O *Bursera fagaroides* (Kunth) Engl.
H *Bursera graveolens* (Kunth) Triana & Planch.
O *Bursera heteresthes* Bullock
O ***Bursera instabilis*** McVaugh & Rzed. Category C (Nay Jal Mich Col Gro Oax). Mature forest fragments.
O *Bursera lancifolia* (Schltdl.) Engl.
O *Bursera longipes* (Rose) Standl.
O *Bursera schlechtendalii* Engl.
H O *Bursera simaruba* (L.) Sarg.

Cactaceae

H *Pereskia autumnalis* (Eichlam.) Britton & Rose
O *Pereskia lychnidiflora* DC.
O *Pereskiopsis diguetti* (F.A.C.Weber) Britton & Rose

Capparidaceae

O ***Capparis angustifolia*** Kunth Category B (Mich Gro Oax). Mature forest fragments.
O *Capparis baduca* L.
O *Capparis flexuosa* (L.) L.
H *Capparis frondosa* Jacq.
O *Capparis incana* Kunth
H O *Capparis indica* (L.) Druce
O *Capparis odoratissima* Jacq.
O *Capparis verrucosa* Jacq.
O *Cleome pilosa* Benth.
O *Crataeva tapia* L.
O ***Forchhammeria lanceolata*** Standl. Category B (Oax Gro). Mature forest fragments and fallow.
O *Forchhammeria pallida* Liebm.
H O *Morisonia americana* L.

Caricaceae

H O *Carica papaya* L.

O *Jacaratia mexicana* A.DC.

Cecropiaceae

O *Cecropia obtusifolia* Bertol.

H *Cecropia peltata* L.

Celastraceae

O *Crossopetalum uragoga* (Jacq.) Kuntze

O *Hippocratea acapulcensis* Kunth

O *Hippocratea celastroides* Kunth

Chrysobalanaceae

H O *Chrysobalanus icaco* L.

H *Couepia polyandra* (Kunth) Rose

H O *Licania arborea* Seem.

H O *Licania platypus* (Kunth) Rose

Clethraceae

See Cyrillaceae

Cochlospermaceae

See Bixaceae

Combretaceae

O ***Bucida macrostachya*** Standl.
Category C (Oax Chis Bel Guat Hon Nic). Mature forest fragmentss, occasional fallows.

O ***Bucida wigginsiana*** Miranda
Category B (Gro Oax) Mature forest fragments.

O **Terminalia catappa* L.

Compositae

O ***Chromolaena glaberrima*** (DC.) R.M.King & H.Rob.
Category C (Oax – not limited to PDF). Principally oak forest.

H *Eleutheranthera ruderalis* (Sw.) Sch.Bip.

O *Eupatorium scabrellum* B.L.Rob.

O *Lagascea helianthifolia* Kunth

O *Lasianthaea fruticosa* (L.) K.M.Becker var. *michoacana* (Blake) K.M.Becker

O *Montanoa grandiflora* Alaman ex DC.

O *Montanoa speciosa* DC.

O ***Montanoa tomentosa*** Cerv. ssp. ***microcephala*** (Sch.Bip.) V.A.Funk
Category C (Oax – not limited to PDF). Principally seasonal oak forest.

H *Polymnia maculata* Cav.

O *Roldana eriophylla* (Greenm.) H.Rob. & Brettell

O *Trixis inula* Crantz

O *Trixis mexicana* Lex.

O ***Trixis pterocaulis*** B.L.Rob. & Greenm.
Category B (Sin Jal Col Oax). Mature semi-deciduous forest fragments.

O ***Trixis silvatica*** B.L.Rob. & Greenm.
Category A. Mature forest fragments.

O *Verbesina fastigiata* B.L.Rob. & Greenm.

H *Verbesina gigantea* Jacq.

H *Verbesina gigantoides* B.L.Rob.

O ***Verbesina oaxacana*** DC.
Category C (Oax – not limited to PDF) Fallows.

O *Verbesina turbacensis* Kunth

H O *Vernonanthera patens* (Kunth) H. Rob

O *Vernonia triflosculosa* Kunth var. *palmeri* (Rose) B.L.Turner

Convolvulaceae

O *Ipomoea wolcottiana* Rose

Cyrillacaea

O *Clethra mexicana* DC.

Dilleniaceae

H O *Curatella americana* L.

Ebenaceae

O *Diospyros digyna* Jacq.

H O *Diospyros salicifolia* Humb. & Bonpl. ex Willd.

Erythroxylaceae

H *Erythroxylum areolatum* L.

O *Erythroxylum havanense* Jacq.

O *Erythroxylum rotundifolium* Lunan

Euphorbiaceae

O ***Acalypha liebmannii*** (Muell. Arg.) Lundell

Category B (Oax Gro). Seasonal oak forest.
H O *Acalypha schiedeana* Schltdl.
H *Cnidoscolus aconitifolius* (Mill.) I.M.Johnst.
H O *Cnidoscolus tubulosus* (Muell. Arg.) I.M.Johnst.
O ***Croton axillaris*** Muell. Arg.
Category C (Oax Chis SLP Tam Guat Nic CR). Mature forest fragments.
H *Croton cortesianus* Kunth
O *Croton fragilis* Kunth
H *Croton guatemalensis* Lotsy
O *Croton niveus* Jacq.
H *Croton payaquensis* Standl.
O ***Croton ramillatus*** Croizat
Category C (Gro Oax Ver – not limited to PDF). Mature forest fragments.
O *Croton rhamifolius* Kunth
O ***Croton septemnervius*** McVaugh
Category C (Jal Gro Oax – not limited to PDF). Mature forest fragments and fallows.
O *Croton suberosus* Kunth
O *Euphorbia colletioides* Benth.
O *Euphorbia pulcherrima* Willd. ex Klotzsch
O *Euphorbia scabrella* Boiss.
H O *Euphorbia schlechtendalii* Boiss.
O *Garcia nutans* Vahl
O ***Jatropha alamani*** Muell. Arg.
Category A Mature forest fragments and fallows.
H O *Jatropha curcas* L.
H *Jatropha gossypifolia* L.
O *Jatropha malacophylla* Standl.
O ***Jatropha sympetala*** Standl. & Blake
Category A Mature forest fragments and fallows.
H O *Manihot aesculifolia* (Kunth) Pohl
O *Manihot chlorosticta* Standl. & Goldman
O *Manihot dulcis* (J.F.Gmel.) Pax
O ***Manihot oaxacana*** D.J.Rogers & Appan
Category A Mature forest fragments and fallows.
H *Margaritaria nobilis* L.f.
O *Pedilanthus tithymaloides* (L.) Poit.
H *Phyllanthus acuminatus* Vahl
O *Phyllanthus mocinianus* Baill.
O *Phyllanthus nobilis* (L. f.) Muell. Arg.
H O **Ricinus communis* L.
O *Sapium lateriflorum* Hemsl.
O *Sapium macrocarpum* Muell.

Fagaceae
O *Quercus acutifolia* Née
O *Quercus magnoliifolia* Née
O *Quercus obtusata* Humb.& Bonpl.
H *Quercus oleoides* Schltdl. & Cham.
O *Quercus peduncularis* Née

Flacourtiaceae
O *Casearia aculeata* Jacq.
O *Casearia arguta* Kunth
H O *Casearia corymbosa* Kunth
H O *Casearia sylvestris* Swartz. var. *sylvestris*
O *Casearia tremula* Griseb. ex C.Wright
H ***Casearia williamsiana*** Sleumer
Category C (Hon, Nic- not endemic to PDF) Disturbed forest fragments.
O *Homalium racemosum* Jacq.
H O *Prockia crucis* P.Browne ex L.
O ***Samyda mexicana*** Rose
Category C (Jal Gro Oax Ver – not limited to PDF) Mature forest fragnments.
H O *Xylosma flexuosa* (Kunth) Hemsl.

Guttiferae
H O *Calophyllum brasiliense* Cambess. var. *rekoi* Standl.
H *Clusia lundellii* Standl.
H *Rheedia intermedia* Pittier
O *Vismia mexicana* Schltdl.

Hernandiaceae
H *Gyrocarpus americanus* Jacq.
O *Gyrocarpus jatrophifolius* Domin
O ***Gyrocarpus mocinnoi*** Espejo
Category C (Oax Gro Chis Pue Guat). Mature forest fragments and fallows.

Hippocrateceae
See Celastraceae

Hydrophyllaceae

O *Wigandia urens* (Ruiz & Pav.) Kunth

Julianaceae

See Anacardiaceae

Labiatae

H *Callicarpa acuminata* Kunth
H *Cornutia pyramidata* L.
O ***Hyptis tomentosa*** Poit.
Category C (Oax Chis Ver – not limited to PDF) Mature forest fragments, fallows and farmland.
H *Salvia tiliaefolia* Vahl
H **Tectona grandis* L.
H *Vitex gaumeri* Greenm.
O *Vitex hemsleyi* Briq.
O *Vitex mollis* Kunth
O *Vitex pyramidata* Rob.

Lauraceae

H **Cinnamomum zeylanicum* Nees
O *Nectandra salicifolia* (Kunth) Nees
H O *Persea americana* Mill.
H ***Persea caerulea*** (Ruiz & Pav.) Mez
Category C (ELS Hon Nic CR Pan) Disturbed forest fragments.
O *Phoebe cinnamomifolia* (Kunth) Nees

Leguminosae (Caesalpinioideae)

O *Bauhinia divaricata* L.
H *Bauhinia pauletia* Pers.
O *Bauhinia subrotundifolia* Cav.
H O *Bauhinia ungulata* L.
O ***Brongniartia bracteolata*** Micheli
Category B (Oax Chis). Mature forest fragments, occasional fallows and farmland.
O ***Caesalpinia coccinea*** G.P.Lewis & J.L.Contr.
Category A. Forest fragments and edges.
H O *Caesalpinia coriaria* (Jacq.) Willd.
H O *Caesalpinia eriostachys* Benth.
O *Caesalpinia exostemma* DC.
O ***Caesalpinia hughesii*** G.P.Lewis
Category B (Oax Gro Col). Forest fragments and edges.
O ***Caesalpinia mollis*** (Kunth) Spreng.
Category C (Oax Chis Yuc -not endemic to PDF).
O *Caesalpinia platyloba* S.Watson
H O *Caesalpinia pulcherrima* (L.) Sw.
O *Caesalpinia sclerocarpa* Standl.
O *Caesalpinia velutina* (Britton & Rose) Standl.
H *Cassia grandis* L.
H **Cassia siamea* Lam.
O *Chamaecrista nictitans* (L.) Moench. var. *jaliscensis* (Greemn.) Irwin & Barneby
O ***Cyanometra oaxacana*** Brandegee
Category C (Jal Col Gro Oax Chis). Mature forest fragments.
H O *Delonix regia* (Bojer & Hook.) Raf.
H *Haematoxylum brasiletto* H.Karst.
H O *Hymenea courbaril* L.
H *Parkinsonia aculeata* L.
H O *Poeppigia procera* (Spreng.) C.Presl.
H O **Senna alata* (L.) Roxb.
O *Senna atomaria* (L.) Irwin & Barnaby
H *Senna emarginata* (L.) Irwin & Barneby
O *Senna fruticosa* (Mill.) Irwin & Barneby
H O *Senna holwayana* (Rose) Irwin & Barneby
O *Senna mollissima* (Willd.) Irwin & Barneby
O *Senna nicaraguensis* (Benth.) Irwin & Barneby
H *Senna occidentalis* (L.) Link
H O *Senna pallida* (Vahl) Irwin & Barnaby
O *Senna quinquangulata* (L.C.Rich) Irwin & Barneby
H *Senna skinneri* (Benth.) Irwin & Barnaby
O *Senna uniflora* (Mill.) Irwin & Barneby
H O **Tamarindus indica* L.

Leguminosae (Mimosoideae)

H O *Acacia angustissima* (Mill.) Kuntze
O *Acacia cochliacantha* Humb. & Bonpl. Ex Willd
H O *Acacia collinsii* Saff.
H O *Acacia cornigera* (L.) Willd.
H O *Acacia farnesiana* (L.) Willd.
H O *Acacia hindsii* Benth.
O *Acacia macrocantha* Humb. & Bonpl. ex Willd.

H *Acacia mangium*
O *Acacia pennatula* (Cham. & Schltdl.) Benth.
O *Acacia picachensis* Brandegee
H O *Albizia adinocephala* (Donn.Sm.) Britton & Rose
H O *Albizia guachapele* (Kunth.) Harms [=Pseudosamanea guachapele (Kunth) Harms]
O *Albizia occidentalis* Brandegee [=Hesperalbizia occidentalis (Brandegee) Barneby & J.W.Grimes]
H *Albizia niopoides* (Benth.) Burkart var. *niopoides*
H *Albizia saman* (Jacq.) F. Muell. [=Samanea saman (Jacq.) Merill]
O *Calliandra acapulcensis* Britton & Rose
O *Calliandra emarginata* (Humb. Ex Willd.) Benth.
O ***Calliandra hirsuta*** (G.Don) Benth. Category C (Gro Oax Chis Pue – not limited to PDF). Farm land.
O *Calliandra houstoniana* (Mill.) Standl.
O *Calliandra tergemina* (L.) Benth.
H O *Chloroleucon mangense* (Jacq.) Britton & Rose var. *leucospermum* (Brandegee) Barneby & J.W.Grimes
H O *Enterolobium cyclocarpum* (Jacq.) Griseb.
O ***Havardia campylacanthus*** (L.Rico & M.Sousa) Barneby & J.W.Grimes Category C (Mich Gro Oax Bel Nic Hon). Forest fragments and farmland.
H *Inga sapindoides* Willd.
H O *Inga vera* Willd.
O *Leucaena esculenta* (Sessé & Moc. ex DC.) Benth.
O *Leucaena lanceolata* S.Watson var. *sousae* (S. Zárate) C.E.Hughes
H O *Leucaena leucocephala* (Lam.) de Wit
O *Leucaena macrophylla* Benth.
H ***Leucaena salvadorensis*** Standl. Category B (ELS Nic Hon). Distrubed forest fragments and farmland.
H *Leucaena shannonii* Donn.Sm.
H O *Lysiloma acapulcense* (Kunth) Benth.
H O *Lysiloma auritum* (Schltdl.) Benth.
H O *Lysiloma divaricatum* (Jacq.) J.F.Macbr.
H O *Mimosa albida* Humb. & Bonpl. ex Willd.
O ***Mimosa albida*** Humb. & Bonpl. ex Willd. var. ***pochutlensis*** R.Grether Category A. Disturbed forest fragments.
O *Mimosa arenosa* (Willd.) Poir.
O ***Mimosa eurycarpa*** B.L.Rob. Category C (Mich Col Oax – not limited to PDF). Mature forest fragments.
H ***Mimosa panamensis*** (Benth.) Standl. Category C (Hon Pan – not limited to PDF). Farmland.
H O *Mimosa platycarpa* Benth.
H *Mimosa pudica* L.
O ***Mimosa robusta*** R.Grether Category C (Jal Nay Gro Oax – not limited to PDF) Farmland.
H *Mimosa somnians* Humb. & Bonpl. ex Willd.
H O *Mimosa tenuiflora* (Willd.) Poir.
O *Piptadenia flava* (Spreng. ex DC.) Benth.
O *Piptadenia obliqua* (Pers.) J.F.Macbr.
H O *Pithecellobium dulce* (Roxb.) Benth.
O *Pithecellobium lanceolatum* (Humb. & Bonpl. ex Willd.) Benth.
O *Pithecellobium seleri* Harms
O *Prosopis juliflora* (Sw.) DC.
O *Zapoteca formosa* (Kunth) H.M.Hern. ssp. *rosei* (Wiggins) H.M.Hern.
O *Zapoteca formosa* (Kunth) H.M.Hern. ssp. *formosa*
O ***Zapoteca tehuana*** H.M.Hern. Category A. Mature forest fragments.

Leguminosae (Papilionoideae)

H *Acosmium panamense* (Benth.) Yakoul
O *Aeschynomene americana* L.
O *Aeschynomene compacta* Rose
O *Aeschynomene fascicularis* Schltdl. & Cham.
H O *Andira inermis* (Wright) Kunth
O *Apoplanesia paniculata* C.Presl.
O *Coursetia caribaea* (Jacq.) Lavin var. *serica* (A.Gray) Lavin
O *Coursetia glandulosa* A.Gray
H O *Coursetia polyphylla* Brandegee
H *Dalbergia glabra* (Mill.) Standl.

O *Dalbergia granadillo* Pittier
O *Dalea carthagenensis* (Jacq.) J.F.Macbr.
H *Dalea scandens* (Mill.) R.T.Clausen
O *Desmodium nicaraguense* Benth.
H *Erythrina fusca* Lour.
O *Erythrina lanata* Rose
H O *Gliricidia sepium* (Jacq.) Steud.
O *Hybosema ehrenbergii* (Schltdl.) Harms[2]
O *Indigofera fruticosa* Rose
O *Indigofera lancifolia* Rydb.
O *Indigofera panamensis* Rydb.
O ***Indigofera platycarpa*** Rose
Category C (Gro Oax Pue Mor – not limited to PDF). Mature forest fragments.
O *Lonchocarpus acuminatus* (Schltdl.) Sousa
O ***Lonchocarpus constrictus*** Pittier
Category C (Jal Mich Col Gro Oax). Mature forest fragments and occasionally fallows.
O ***Lonchocarpus emarginatus*** Pittier
Category B (Oax Chis). Mature forest fragments.
H O *Lonchocarpus guatemalensis* Benth.
O *Lonchocarpus hermanii* M.Sousa
O *Lonchocarpus lanceolatus* Benth.
O ***Lonchocarpus longipedicellatus*** Pittier
Category B (Jal Gro Oax). Mature forest fragments.
H *Lonchocarpus minimiflorus* Donn.Sm.
H O *Lonchocarpus phaseolifolius* Benth.
H O *Lonchocarpus rugosus* Benth.
O *Lonchocarpus rugosus* Benth. ssp. *apricus* (Lundell) M.Sousa
H O *Machaerium biovulatum* Micheli
O *Machaerium salvadorense* (Donn.Sm.) Rudd
H O *Myrospermun frutescens* Jacq.
O *Piscidia carthagenensis* Jacq.
O *Piscidia grandifolia* (Donn.Sm.) I.M.Johnst.
H O *Platymiscium dimorphandrum* Donn.Sm.
O ***Platymiscium lasiocarpum*** Sandwith
Category C (Jal Mich Gro Oax – not limited to PDF). Mature forest fragments
O *Pterocarpus acapulcensis* Rose
O *Pterocarpus rohrii* Vahl
O *Tephrosia leiocarpa* A.Gray
O *Tephrosia multifolia* Rose

Loganiaceae
See Buddlejaceae

Lythraceae
O *Adenaria floribunda* Kunth
H **Lawsonia inermis* L.
H *Pehria compacta* (Rusby) Sprague

Malpighiaceae
O *Bunchosia caroli* W. R. Anderson
O ***Bunchosia discolor*** Turcz. ex Char.
Category A. Mature forest fragments.
H ***Bunchosia guatemalensis*** Ndzu
Category C (Chis Guat Hon – not limited to PDF). Disturbed forest fragments.
H *Bunchosia odorata* (Jacq.) Kunth
H O *Byrsonima crassifolia* (L.) Kunth
H O *Heteropterys laurifolia* (L.) A.Juss.
H *Hiraea velutina* Nied.
O *Malpighia emarginata* DC.
O *Malpighia glabra* L.
O *Malpighia ovata* Rose
H *Tetrapterys arcana* Morton

Malvaceae
O **Abelmoschus esculentus* (L.) Moench
O ***Abutilon grandidentatum*** Fryxel.
Category C (Oax Chis – not limited to PDF). Mature forest fragments.
H *Abutilon hirtum* (Lam.) Sweet
O **Gossypium arboreum* L.
O *Gossypium aridum* (Rose & Standl.) Skov.
H O *Gossypium hirsutum* L.
O *Gossypium irenaeum* Lewton
O ***Hibiscus kochii*** Fryxell
Category B (Gro Oax.). Mature forest fragments.
O ***Hibiscus peripteroides*** Fryxell
Category C (Oax SLP – not limited to PDF). Reverine forest.
O *Hibiscus sabdariffa* L.
H O *Malvaviscus arboreus* Cav.
H O *Sida acuta* Burm.f.
O *Sida cordifolia* L.
H *Sida paniculata* L.

O *Sida rhombifolia* L.

Melastomataceae
H *Conostegia subcrustulata* (Beurl.) Triana
O *Conostegia xalapensis* (Bonpl.) D.Don ex DC.
H *Miconia albicans* (Sw.) Triana
H *Miconia argentea* (Sw.) DC.

Meliaceae
H O **Azadirachta indica* A.Juss.
H O *Cedrela odorata* L.
H O *Guarea glabra* Vahl
O **Melia azadirachta* L.
H O ***Swietenia humilis*** Zucc.
Vulnerable. Forests and farmland.
O *Swietenia macrophylla* G. King
H *Trichilia americana* (Sessé & Moc.) T.D.Penn
O *Trichilia havanensis* Jacq.
H O *Trichilia hirta* L.
H O *Trichilia martiana* C.DC.
H O *Trichilia trifolia* L.

Menispermaceae
O *Hyperbaena mexicana* Miers

Monimiaceae
H *Siparuna nicaraguensis* Hemsl.

Moraceae
H **Artocarpus altilis* (Parkinson) Fosberg
H O *Brosimum alicastrum* Sw.
H *Castilla elastica* Sessé ex Cerv.
H *Ficus americana* Aubl.
H O *Ficus benjamina* L.
O *Ficus calyculata* Mill.
O *Ficus cotinifolia* Kunth
H *Ficus glabrata* Kunth
O *Ficus goldmanii* Standl.
O *Ficus insipida* Willd.
H O *Ficus maxima* Mill.
H O *Ficus obtusifolia* Kunth
H O *Ficus ovalis* (Liebm.) Miq.
O *Ficus pertusa* L.f.
O *Ficus petiolaris* Kunth
O *Ficus subrotundifolia* Greenm.
O *Ficus trigonata* L.
H O *Maclura tinctoria* (L.) D. Don ex Steud.
O *Trophis racemosa* (L.) Urb.

Myrsinaceae
O *Ardisia compressa* Kunth
H O *Ardisia revoluta* Kunth

Myrtaceae
H *Eugenia acapulcensis* Steud.
O *Eugenia farameoides* A.Rich.
H ***Eugenia hondurensis*** Ant. Molina
Category B (Oax? Hon Nic). Disturbed forests and farmland.
O ***Eugenia salamensis*** Donn.Sm. var. ***rensoniana*** (Standl.) McVaugh
Category B (Oax Guat CR). Mature forest fragments.
H O *Psidium guajava* L.
H O *Psidium guineense* Sw.
O *Psidium sartorianum* (O.Berg) Nied.

Nyctaginaceae
H O *Bougainvillea x buttiana* Holt. & Standl.
H ***Grajalesia fasciculata*** (Standl.) Miranda
Category C (Oax Guat ELS Hon Nic). Disturbed forest and farmland.
H O *Neea psychotrioides* Donn.Sm.
O *Pisonia aculeata* L.
O *Salpianthus arenarius* Humb. & Bonpl.
O ***Torrubia macrocarpa*** Miranda
[=Guapira macrocarpa Miranda?]
Category C (Jal Mich Mor Oax Pue) Mature forest fragments, occasionally farmland.

Ochnaceae
O *Ouratea lucens* (Kunth) Engl.

Olacaceae
H O *Schoepfia schreberi* J.F.Gmel.
H O *Ximenia americana* L.

Opiliaceae
O *Agonandra obtusifolia* Standl.
O *Agonandra racemosa* (DC.) Standl.

Oxalidaceae
H **Averrhoa carambola* L.

Palmae
H O *Acrocomia mexicana* Karw. ex Mart.
H O *Cocos nucifera* L.

Papaveraceae
O *Bocconia arborea* S.Watson

Picramniaceae
H O *Alvaradoa amorphoides* Liebm.

Piperaceae
H *Piper amalago* L.
H *Piper marginatum* Jacq.

Polygonaceae
H *Coccoloba caracasana* Meisn.
O *Coccoloba liebmannii* Lindau
O *Coccoloba schiedeana* Lindau
H *Coccoloba venosa* L.
O *Podopterus cordifolius* Rose & Standl.
O *Podopterus mexicanus* Humb. & Bonpl.
O *Ruprechtia fusca* Fernald.
H O *Ruprechtia pallida* Standl.

Proteaceae
H *Roupala montana* Aubl.

Rhamnaceae
H *Colubrina arborescens* (Mill.) Sarg.
O *Gouania polygama* (Jacq.) Urb.
H O *Karwinskia calderonii* Standl.
O *Karwinskia humboldtiana* (Roem. & Schult.) Zucc.

Rubiaceae
H O *Alibertia edulis* (Rich.) A. Rich. ex DC.
H O *Calycophyllum candidissimun* (Vahl) DC.
O *Chiococca alba* (L.) Hitchc.
O ***Chiococca filipes*** Lundell
Category C (Oax Chis Hon – not limited to PDF). Seasonal oak forest.
H *Chomelia spinosa* Jacq.
H **Coffea arabica* L.
H *Coutarea hexandra* (Jacq.) K.Schum.
O *Exostema caribaeum* (Jacq.) Roem. & Schult.
H *Exostema mexicanum* A.Gray
H O *Genipa americana* L.
H ***Guettarda deamii*** Standl.
Category B (Guat ELS Hon Nic). Disturbed forest fragments.
O *Guettarda elliptica* Sw.
O ***Guettarda galeottii*** Standl.
Category B (Sin Nay Oax). Fallows.
H *Hamelia patens* Jacq.
O *Hamelia versicolor* A.Gray
O *Hintonia latiflora* (Sessé & Moc. ex DC.) Bullock
H *Palicourea crocea* (Sw.) Roem. & Schult.
O *Psychotria horizontalis* Sw.
H O *Psychotria microdon* (DC.) Urb.
H O *Psychotria pubescens* Sw.
O *Psychotria tenuifolia* Sw.
O *Randia aculeata* L.
O *Randia armata* (Sw.) DC.
O ***Randia cinerea*** (Fernald) Standl.
Category B (Oax Gro). Fallows.
H *Randia cookii* Standl.
H *Randia echinocarpa* Moc. & Sessé ex DC.
O *Randia laevigata* Standl.
O *Randia malacocarpa* Standl.
O ***Randia nelsonii*** Greenm.
Category C (Sin Mich Oax Ver – not limited to PDF). Mature forest fragments.
H ***Randia pleiomeris*** Standl.
Category C (Guat ELS Hon – not limited to PDF). Disturbed forest fragments and farmland.
O *Randia tetracantha* (Cav.) DC.
O *Randia thurberi* S.Watson
H O ***Rondeletia deamii*** (Donn.Sm) Standl.
Category C (Oax Guat Hon Nic – not limited to PDF). Forest fragments and farmland.
O *Rondeletia leucophylla* Kunth

Rutaceae

O *Amyris balsamifera* L.
H O **Citrus aurantifolia* (Christm.) Swingle
H **Citrus aurantium* L.
H **Citrus limeta* Risso
H **Citrus paradisi* Macfad.
H **Citrus reticulata* Blanco
H O **Citrus sinensis* Osbeck
H O *Esenbeckia berlandieri* Baill. ex Hemsl. ssp. *litoralis* (Donn.Sm.) Kaastra
O **Murraya paniculata* (L.) Jack
O *Zanthoxylum affine* Kunth
H *Zanthoxylum anodynum* Ant. Molina
O *Zanthoxylum arborescens* Rose
H *Zanthoxylum culantrillo* Kunth
O *Zanthoxylum fagara* (L.) Sarg.
H *Zanthoxylum microcarpum* Griseb.

Salicaceae

O *Salix bonplandiana* Kunth

Sapindaceae

H *Allophylus psilospermus* Radlk.
H *Allophylus racemosus* Sw.
O *Cupania dentata* DC.
H *Cupania glabra* Sw.
H *Cupania guatemalensis* Radlk.
O *Dodonaea viscosa* Jacq.
H *Melicoccus bijugatus* Jacq.
H O *Sapindus saponaria* L.
H O *Thouinia serrata* Radlk.
O *Thouinia villosa* DC.
H O *Thouinidium decandrum* (Humb. & Bonpl.) Radlk.

Sapotaceae

H *Chrysophyllum cainito* L.
O *Chrysophyllum mexicanum* Brandegee ex Standl.
H *Pouteria campechiana* (Kunth) Baehni
H *Pouteria sapota* (Jacq.) Moore & Stearn
H O *Sideroxylon capiri* (A.DC.) Pittier ssp. *tempisque* (Pittier) T.D.Penn.
O *Sideroxylon cartilagineum* (Cronquist) T.D.Penn.
O *Sideroxylon celastrinum* (Kunth) T.D.Penn.
H O *Sideroxylon obtusifolium* (Roem. & Schult.) T.D.Penn.

Simaroubaceae

O ***Castela retusa*** Liebm.
Category A. Mature forest fragments.
H O *Quassia simarouba* L.f. (=*Simarouba glauca* DC.)
O ***Recchia mexicana*** Moc. & Sessé ex DC.
Category B (Oax Jal). Mature forest fragments, occasional fallows.

Solanaceae

H *Cestrum dumetorum* Schltdl.
O *Juanulloa mexicana* (Schltdl.) Miers
H *Solanum americanum* Mill.
H *Solanum erianthum* D.Don
H *Solanum hazenii* Britton
H *Solanum hirtum* Vahl
H *Solanum torvum* Sw.
H *Solanum verbascifolium* L.

Staphylaceae

H *Turpinia occidentalis* (Sw.) G.Don.

Sterculiaceae

H *Ayenia micrantha* Standl.
O *Ayenia palmeri* S.Watson
H O *Guazuma ulmifolia* Lam.
O *Helicteres mexicana* Kunth
O *Melochia glandulifera* Standl.
H O *Melochia nodiflora* Sw.
O *Melochia tomentosa* L.
O ***Physodium oaxacanum*** Dorr & Barnett[3]
Category B (Oax Chis).
H *Sterculia apetala* (Jacq.) H.Karst.
H *Theobroma cacao* L.
O ***Waltheria conzatii*** Standl.
Category A. Fallow.
H O *Waltheria indica* L.

Theophrastaceae

H O *Jacquinia macrocarpa* Cav.

O *Jacquinia seleriana* **Urb. & Loes.**
Category A

Tiliaceae

H *Apeiba tibourbou* Aubl.
O *Heliocarpus donnell-smithii* Rose
O *Heliocarpus mexicanus* (Turcz.) Sprague
O ***Heliocarpus occidentalis*** Rose
Category C (Sin Jal Nay Col Gro Oax). Mature forest fragments.
O *Heliocarpus pallidus* Rose
H O *Luehea candida* (Moc. & Sessé ex DC.) M.Mart.
H *Luehea speciosa* Willd.
O *Muntingia calabura* L.
O *Trichospermum mexicanum* (DC.) Baill.
H O *Triumfetta bogotensis* DC.
H *Triumfetta calderoni* Standl.
O *Triumfetta dumetorum* Schltdl.
O ***Triumfetta heliocarpoides*** Bullock
Category B (Gro, Oax) Seasonal oak forest.
O *Triumfetta paniculata* Hook. & Arn.

Trigoniaceae

H ***Trigonia rugosa*** Benth.
Category C (Guat ELS Hon Nic – not limited to PDF) Disturbed forest fragments.

Turneraceae

O *Turnera ulmifolia* L.

Ulmaceae

H O *Celtis iguanaea* (Jacq.) Sarg.
H O *Trema micrantha* (L.) Blume

Urticaceae

H *Myriocarpa bifurcata* Liebm.
H *Myriocarpa longipes* Liebm.
O *Urera baccifera* (L.) Gaudich ex Wedd.
O *Urera caracasana* (Jacq.) Griseb.

Verbenaceae

see also Labiatae
O ***Aloysia chiapensis*** Moldenke
Category B (Oax Chis). Solar.
O *Lantana camara* L.
H *Lantana urticifolia* Mill.
O *Lantana velutina* M.Martens & Galeotti
H *Lippia alba* (Mill.) N.E.Br.
H *Lippia cardiostegia* Benth.
O *Lippia umbellata* Cav.
H *Rehdera trinervis* (S.F.Blake) Moldenke

Violaceae

O *Hybanthus mexicanus* Ging.

Zamiaceae

O *Dioon edule* Lindl. var. *sonorense* (De Luca, Sabato & Vázq. Torres) McVaugh & Pérez de la Rosa

Zygophyllaceae

O *Guaiacum coulteri* A.Gray
H ***Guaiacum sanctum*** L.
Endangered. Disturbed forest fragments.

Notes

[1] Odontonema = Justica: Mabberley 1997
[2] Hybosema = Gliricidia (Mabberley 1997)
[3] Physodium = Melochia (Mabbberley 1997)

Appendix 5: Guide to key institutions

In this Appendix we provide a summary, which is not necessarily definitive, of the principal institutions and organizations which participated in the research and/or are of potential importance for the implementation of conservation strategies in the MTDF.

Oaxaca

- Centro de Soporte Ecológico (Ecological Support Centre). Bahía de Santa Cruz 119, Sector T, La Crucecita, Bahías de Huatulco, Oaxaca, México. Tel: (958) 70405. CSE is based on the Oaxacan coast, and promotes conservation and rural development activities in a number of catchments in and around the Huatulco area, such as reforestation and the promotion of sustainable forest management. One of the communities where CSE works is the CUBOS study community Santa María Petatengo.
- Centro Interdisciplinario de Investigación para el Desarrollo Rural (Interdisciplinary Centre for Research in Rural Development) - CIIDIR. Calle Hornos s/n Indeco c.p. 71230 Xoxocotlán, Oaxaca, México. Tel: (951) 70400. Email: cidiroax@vmredi.ipn.mx. CIIDIR is a research centre, which sponsors and carries out research and rural development activities in a number of communities in Oaxaca, including the CUBOS study community Santa María Petatengo.
- Comisión Oaxaqueña de Defensa Ecológica (Oaxacan Comisión for Ecological Defence) - CODE. Pino Suárez 901-2 c.p. 68000 Oaxaca, Oaxaca, México. Tel. (951) 38212. Email: code@infosel.net.mx. CODE is an umbrella organization of NGOs involved in conservation in Oaxaca.
- Grupo Autónomo de Investigaciones Ambientales, A.C. (Autonomous Environmental Research Group) - Calle Crespo 520-A, Centro Oaxaca, Oaxaca CP 68000, México Tel. (951) 5147528. Email: gaia@spersaoaxaca. GAIA has offices in both Oaxaca city and Santa María Huatulco, on the coast. It works in community-based rural development and conservation in communities in Santa María Huatulco municipality and surrounding areas, and has also been involved in the recent established Huatulco National Park.
- Grupo Mesófilo (Mesophyllous Group). Pino Suárez 205 c.p. 68000, Oaxaca, Oaxaca, México. Tel.: (951) 62835. Email: mesofilo@oax1.telmex.net.mx. An NGO which works principally in the Sierra Madre area of Oaxaca, but has carried out occasional activities related to the dry forest, including the preparation for CUBOS of a study of the policy context related to dry forest conservation.
- Instituto Estatal de Ecología de Oaxaca (Oaxaca State Ecology Institute) - IEEO. Libres 511-A c.p. 68000, Oaxaca, Oaxaca, México. Tel.: (951) 33288. Email: ecologiaoax@oaxaca.mx. The State level ecological institute in Oaxaca, which promotes initiatives of the State government in relation to conservation and environmental protection.
- Secretaría del Medio Ambiente, Recursos Naturales y Tierras (Environment, Natural Resources and Lanas Secretariat) - SEMARNAT. Sabinos 402, Col. Reforma c.p. 68050, Oaxaca, Oaxaca, México. The Oaxaca office of the Federal entity charged with environmental protection and the planning and regulation of natural resource use.
- Sociedad para el Estudio de los Recursos Bióticos de Oaxaca, A.C. (Society for the Study of the Biotic Resources of Oaxaca) - SERBO. Carretera Internacional KM 7 No. 22, San Sebastian Tutla, Oaxaca. c.p.71246, México. Tel.: (951) 5032100. Email:

serbo@antequera.com. An NGO which has carried out a large number of scientific studies throughout Oaxaca, including in the central dry forest area of the coastal region. It has good GIS and botanical capacity.

- WWF Regional Office/Oaxaca Programme. Jazmines 217, Col. Reforma, 68050 Oaxaca, Oaxaca, México. Tels: (951) 36723/36729. Email:wwfoax@antequera.com. WWF has for a number of years worked in coordinating conservation activities in Oaxaca, and has acted as an important channel of funds to local NGOs.

Honduras

- Instituto de Conservación y Desarrollo Forestal (Institute for Forest Conservation and Development) – ICF. Tel.: (504) 223 4346. The Government agency (a dependency of the Ministry of the Presidency) which, under the new Forestry Law (approved by Congress in 2007), took over from AFE-COHDEFOR in 2008 as the forestry authority responsible for regulating tree and forest use.
- Asociación Sureña para la Conservación de la Naturaleza (Southern Association for Nature Conservation) - ASCONA. Centro San José Obrero, Choluteca. A local organization which has carried out small-scale conservation activities including tree planting and environmental education.
- CARE Honduras. Avenida República de Costa Rica, Sub. Lomas de Mayab, Tegucigalpa, Honduras. Tel.: (504) 239 4425. http://www.care.org. One of the largest development NGOs in southern Honduras, whose projects have included a water supply and conservation programme for communities around Cerro Guanacaure, one of the largest forest remnant in the area.
- Comisión para la Defensa de la Fauna y Flora del Golfo de Fonseca (Comisión for the Defence of the Fauna and Flora of the Gulf of Fonseca) - CODDEFFAGOLF. http://www.coddeffagolf.org. Apdo. Postal 3663 Tegucigalpa. Tel./Fax (504) 238-0415. An environmental NGO and pressure group which carries out conservation and rural development activities, such as reforestation aimed at reducing the pressure on the mangroves of the Gulf of Fonseca Ramsar site.
- Conservación de los Recursos Forestales de Honduras (Forest Resource Conservation Project) - CONSEFORH. Email: consefor@hondutel.hn. A project of AFE-COHDEFOR, established with support from ODA/DFID, which has carried out extensive genetic explorations, seed collections and on-station trials, seed orchards and ex situ conservation plantings with dry forest species.
- Programa para la Conservación y el Desarrollo del Medio Ambiente (Environmental Conservation and Development Programme) - PROCONDEMA. Tel.: (504) 882 0028. An NGO linked to the Catholic Church which works in rural development and natural resource conservation, including the promotion of sustainable organic hillside agriculture and local community-based environmental protection committees.
- Programa Nacional para el Desarrollo Rural Sostenible (National Programme for Sustainable Rural Development) – PRONADERS. http://www.pronaders.hn. The programme implemented by the SAG (through the National Direction of Sustainable Rural Development DINADERS) responsible for promoting sustainable rural development, through projects largely funded by international agencies.

- Secretaría de Agricultura y Ganadería (Agriculture and Livestock Secretariat). Tel.: 235 6730. http://www.sag.gob.hn. The Government Ministry with responsibility for agriculture and livestock and rural development.
- Secretaría de Recursos Naturales y Ambiente (Natural Resources and Environment Secretariat). Tel.: 239 1918. http://www.serna.gob.hn. The Government ministry with responsibility for formulating environment and natural resources policy and for regulating biodiversity use. The national focal point for GEF, CBD and CITES.
- Visión Mundial (World Vision). Apartado Postal 3204, Tegucigalpa. Tel.: 236 7024 (Tegucigalpa office). http://www.worldvision.org. An NGO working in rural development in a number of communities in the south.

Regional Institutions

- Centro Agronómico Tropical de Investigación y Enseñanza (CATIE). CATIE 7170, Turrialba, Costa Rica. Tel.: (506) 556 7830. http://www.catie.ac.cr. The largest research and teaching centre in the region, based in Costa Rica, particularly active in the areas of agroforestry and forest management.
- Comisión Centroamericana para el Ambiente y el Desarrollo (Central American Comisión for Environment and Development) - CCAD. Blvd. Orden de Malta No. 470, Urbanización Santa Helena, Antiguo Cuscatlán, El Salvador. Tel.: (503) 289 - 6131, Fax: (503) 289 - 6126/27. http://ccad.sgsica.org/. Regional inter-governmental commission aimed at promoting environmental protection and sustainable development. Implementing agency for the regional plans of the Mesoamerican Biological Corridor.
- Corredor Biológico Mesoamericano (Mesoamerican Biological Corridor). Email: cbm@undp.org. Regional initiative aimed at promoting connectivity throughout Mesoamerica. Currently a project supported by UNDP, GEF, GTZ and CCAD is underway aimed at consolidating the Corridor.

Annex 6: Suggested reading

Conservation through use

Halladay, P. and Gilmour, D.A. (eds) 1995. Conserving Biodiversity Outside of Protected Areas: The role of traditional agro-ecosystems. IUCN, Gland, Switzerland and Cambridge, UK.

Redford, K.H. and Richter, B.D. 1999. Conservation of biodiversity in a world of use. *Conservation Biology* 13(6), 1246-1256.

Wild, R.G. and Mutebi, J. 1996. Conservation through community use of plant resources: Establishing collaborative management at Bwindi Impenetrable and Mgahinga Gorilla National Parks, Uganda. People and Plants Working Paper, UNESCO, Paris.

Botanical research methods

Alexiades, M.N. (ed). 1996. *Selected Guidelines for Ethnobotanical Research: A Field Manual.* The New York Botanical Garden, New York.

Hall, J.B. 1991. Multiple-nearest-tree sampling in an ecological survey of Afromontane catchment forest. *Forest Ecology and Management*, 42, 245-299.

Hawthorne, W.D. 1996. Holes in sums of parts in Ghanaian forest: regeneration scale and sustainable use. *Proceedings of the Royal Society of Edinburgh* 104(B), 75-176.

Margules, C. and Pressey, R. 2000. Systematic conservation planning. *Nature* 405, 243-253.

Martin, G. 1995. *Ethnobotany*. Chapman and Hall, London.

Phillips, O., Vásquez Martínez, R., Núñez Vargas., P., Monteagudo, A.L., Chuspe Zans, M.-E., Galiano Sánchez, W., Peña Cruz, A., Timaná, M., Yli-Halla, M. and Rose, S. 2003. Efficient plot-based floristic assessment of tropical forests. *Journal of Tropical Ecology* 19, 629-645.

Stern, M.J. 1998. Field comparisons of two rapid vegetation assesment techniques with permanent plot inventory data in Amazonian Peru. In: Dallmeier, F. and Comiskey, J.A. (eds) *Forest Biodiversity Research, Monitoring and Modeling: Conceptual Background and Old World Case Studies*, 269-283. UNESCO/Parthenon Publishing Group, New York.

Dry forest botany and ecology

Bye, R. 1995. Ethnobotany of the Mexican tropical dry forest. In: Bullock, S.H., Mooney, H.A. and Medina, E. (eds) *Seasonally Dry Tropical Forests*, 423-438. Cambridge University Press, Cambridge.

Gentry, A.H. 1988. Changes in plant community diversity and floristic composition on environmental and geographical gradients. *Annals of the Missouri Botanical Gardens* 75(1), 1-34.

Gentry, A.H. 1995. Diversity and floristic composition of neotropical dry forests. In: Bullock, S.H., Mooney, H.A. and Medina, E. (eds) *Seasonally Dry Tropical Forests*, 146-194. Cambridge University Press, Cambridge.

Gillespie, T.W., Grijalva, A. and Farris, C.N. 2000.Diversity, composition, and structure of tropical dry forests in Central America. *Plant Ecology* 147, 37-47.

Gordon, J., Hawthorne, W.D., Reyes-García, A., Sandoval, G. and Barrance, A.J. 2004. Assessing landscapes: a case study of tree and shrub diversity in the seasonally dry tropical forests of Oaxaca, Mexico and southern Honduras.*Biological Conservation* 117, 429-442.

Janzen, D.H. and Liesner, R. 1980. Annotated checklist of plants of lowland Guanacaste Province, Costa Rica, exclusive of grasses and non-vascular cryptograms. *Brenesia* 18, 15-90.

Martínez-Yrízar, A., Búrquez, A. and Maass, M. 2000. Structure and functioning of tropical deciduous forest in Western Mexico. In: Robichaux, R.H. and Yetman, D.A. (eds) *The Tropical Deciduous Forest of Alamos: the biodiversity of a threatened ecosystem in Mexico*, 19-35. University of Arizona Press, Tuscon, USA.

Miranda, F. and Hernández, E. 1963. Los tipos de vegetación de México y su clasificación. *Boletin de la Sociedad Botánica Mexicana* 28: 29-179.

Reyes-García, A. and Sousa, M. 1997. Listados Florísticos de México: La Depresión Central de Chiapas: La Selva Baja Caducifolia. UNAM, Mexico City, Mexico.

Salas-Morales, S.H., Saynes-Váquez, A. and Schibli, L. 2003 Flora de la costa de Oaxaca: lista florística de la región de Zimatán. *Boletín de la Sociedad Botánica Mexicana* 72, 21-58.

Trejo, I. and Dirzo, R. 2002. Floristic diversity of Mexican seasonally dry tropical forests. *Biodiversity and Conservation* 11, 2063-2084.

Dry forest conservation status

Challenger, A. 1998. Utilización y conservación de los ecosistemas terrestres de México: pasado, presente y futuro. CONABIO, Mexico City, Mexico.

IUCN Red List 2004. Available at: http://www.redlist.org/

Janzen, D.H. 1988. Tropical Dry Forests: the most endangered major tropical ecosystem. In: Wilson, E.O. (ed.) *Biodiversity*, 130-137. National Academy Press, Washington DC USA.

Lerdau, M., Whitbeck, J. and Holbrook, N.M. 1991. Tropical deciduous forest: death of a biome. *Trends in Ecology and Evolution* 6(7), 201-202.

Murphy, P.G. and Lugo, A.E. 1995. Dry Forests of Central America and the Caribbean. In: Bullock, S.H., Mooney, H.A. and Medina, E. (eds) *Seasonally Dry Tropical Forests*, 9-34. Cambridge University Press, Cambridge.

Trejo, I. and Dirzo, R. 2000. Deforestation of seasonally dry tropical forest: a national and local analysis in Mexico. *Biological Conservation* 94(2), 133-142.

World Wildlife Fund Global 200 Ecoregions. Available at: http://www.worldwildlife.org/science/ecoregions/g200.cfm (accessed 1/2/05).

Dry forest species

Boshier, D.H. and Lamb, A.T. 1997. Cordia alliodora: *Genetics and Tree Improvement.* Tropical Forestry Paper 36, Oxford Forestry Institute, Oxford.

Gordon, J.E., González, M.-A., Vazquez Hernández, J., Ortega Lavariega, R. and Reyes-García, A. 2005. *Guaiacum coulteri*: an over-logged dry forest tree of Oaxaca, Mexico. *Oryx* 39, 1-4.

Hughes, C.E. 1998a. Monograph of *Leucaena* (Leguminosae-Mimosoidae). *Systematic Botany Monographs* 55, 1-244.

Hughes, C.E. 1998b. Leucaena: *a Genetic Resources Manual*. Tropical Forestry Paper 37, Oxford Forestry Institute, Oxford.

Pound, B. and Martínez Cairo, L. 1985. *Leucaena*: su Uso y Cultivación. ODA, London.

Conservation strategies

Barkin, D. and Paillés, C. 1998. Water as an instrument for sustainable regional development. *Conflict Resolution and Transboundary Water Resources.* No. 44, Fall/Winter 1998.

Barrance, A.J., Flores, L., Padilla, E., Gordon, J.E. and Schreckenberg, K. 2003. Trees and farming in the dry zone of southern Honduras I: *campesino* tree husbandry practices. *Agroforestry Systems* 59, 97-106.

Barrance, A.J., Gordon, J.E. and Schreckenberg, K. 2006. Trends, cycles and entry points in the dry forest landscapes of southern Honduras and coastal Oaxaca. In: Mistry, J. and Berardi, A. (eds), *Savannas and Dry Forests – Linking People with Nature*, 53-76. Ashgate Publishing, Abingdon.

Bennett, A.F. 1999. Linkages in the Landscape: the role of corridors and connectivity in wildlife conservation. Gland, Switzerland and Cambridge, UK.

Boshier, D.H., Gordon, J.E. and Barrance, A.J. 2004. Prospects for *circa situm* tree conservation in Mesoamerican dry forest agro-ecosystems. In: Frankie, G.W., Mata, A. and Vinson, S.B. (eds). Biodiversity Conservation in Costa Rica; Learning the Lessons in a Seasonal Dry Forest. University of California Press, Berkeley, California.

Gordon, J.E., Barrance, A.J. and Schreckenberg, K. 2003. Are rare species useful species? Obstacles to the conservation of tree diversity in the dry forest zone agro-ecosystems of Mesoamerica. *Global Ecology and Biogeography* 12, 13-19.

Gordon, J.E., Hawthorne, W.D., Sandoval, G. and Barrance, A.J. 2003. Trees and farming in the dry zone of southern Honduras II: the potential for tree diversity conservation. *Agroforestry Systems* 59, 107-117.

Janzen, D.H. 1986. Guanacaste National Park: Tropical Ecological and Cultural Restoration. Editorial Universidad Estatal a Distancia, San José, Costa Rica.

Social conditions and history

Clarke, C. 2000. Class, Ethnicity and Community in Southern Mexico: Oaxaca's Peasantries. Oxford University Press, Oxford.

Dunk Ravnborg, H. 2003. Poverty and environmental degradation in the Nicaraguan hillsides. *World Development* 31(11), 1933-1946.

Dunn, M.H. 2000. Privatization, land reform and property rights: the Mexican experience. *Constitutional Political Economy* 11, 215-230.

Newson, L. 1992. El Costo de la Conquista. Editorial Guaymuras, Tegucigalpa, Honduras.

Rodríguez Canto A (1996) Historia Agrícola y Agraria de la Costa Oaxaqueña. Universidad Autónoma Chapingo, Mexico.

Simonian, L. 1995. Defending the land of the jaguar: a history of conservation in Mexico. University of Texas Press, Austin.

Stonich, S.C. 1993. “I am Destroying the Land!”. The Political Ecology of Poverty and Environmental Destruction in Honduras. Westview Press.

This book examines the concept of 'conservation through use', using the conservation of tree species diversity in Mesoamerican tropical dry forest in Honduras and Mexico as a case study. It discusses the need to develop conservation strategies based both on a botanical determination of those species most in need of conservation and an understanding of the role these trees play in local livelihoods. Based on a detailed analysis of smallholder farming systems in southern Honduras and coastal Oaxaca and a botanical survey of trees and shrubs in different land use systems in both study areas, the findings confirm the importance of involving the local population in the management and conservation of Mesoamerican tropical dry forest.

The book is directed at researchers in both the socioeconomic and botanical spheres, policy makers at both national and international level, and members of governmental and non-governmental organisations, institutions and projects active in the conservation of tropical dry forest and in rural development in the region.

Overseas Development Institute
FORESTRY RESEARCH PROGRAMME

Overseas Development Institute
111 Westminster Bridge Road
London SE1 7JD, UK

Tel: +44 (0)20 7922 0300
Fax: +44 (0)20 7922 0399
Email: publications@odi.org.uk
Website: www.odi.org.uk

ISBN 978-0-85003-894-1

9 780850 038941 >