Appendix 1: Modeling deforestation baselines using LUCS for the Meseta Purépecha and Calakmul regions in Mexico

By

Fernando Ruiz Noriega
Consejo Civil Mexicano para la Silvicultura Sostenible, A.C.
fruizn@infosel.net.mx

Background:

One of the most challenging issues working with carbon emissions/sequestration projects is developing without-project baselines for determining additionality of projects against which changes in carbon in the project area can be compared This is especially true for projecting future trends in deforestation and other land-use changes that would have occurred in the absence of a project.

Despite the advances in developing project baselines, there are currently no standard practices for developing baselines and thus determining additionality.

This project seeks to develop without-project scenarios at two sites in Mexico: Calkmul in Campeche and Meseta Purépecha in Michoacán, using different methods to determine the most useful and effective method for developing these estimates of likely changes in carbon stocks over time.

To confront this challenge, three viable approaches for developing baselines were identified for predicting changes in land:

1. non-spatial model depending on biophysical and socio-economic drivers (LUCS Model)
2. spatially geo-referenced model, using socioeconomic, demographic, and biophysical drivers (GEOMOD).
3. use of historical tabular data from the project area and/or for nearby proxy areas

All three approaches are basically designed to extrapolate past trends in the use of lands into the future. All of the approaches use models (simple to complex), which provide a conceptual basis for integrating diverse measures into a self-consistent framework and for making meaningful extrapolations across time and space. These approaches have been applied previously to at least four pilot projects in developing countries: (a) Noel Kempff Climate Action Project in Bolivia (forest protection by averted deforestation and logging), (b) Rio Bravo Climate Action Project, Programme for Belize (averted deforestation and forest management), (c) Scolel Te, Mexico (agroforestry), and (d) Guaraqueçaba Climate Action Project in Brazil (averted deforestation and forest degradation and forest restoration).

The advantage of combining all this work is that, with more case-study projects to work with, more conclusive statements about the recommended strategy for future baseline development will be possible.

In this paper we report the results of the non-spatial model, LUCS, applied to both regions: Meseta Purépech and Calakmul. The areas are not the same as those used in the GEOMOD analysis (see products delivered on GEOMOD results), but results can be easily compared. The baselines will be projected for the duration of projects generally proposed by project developers, which last for 20 to 30 years.

Brief Description of LUCS Model:

Non-spatial models depend mainly on socio-economic and biophysical drivers. The LUCS model was developed originally to model rural areas that depend largely upon low-productivity agriculture for subsistence and fuel wood for energy. The model was modified somewhat to widen its applicability, but the basic assumptions are still best adapted to developing regions, where there are multiple forces interacting to drive land use change.

Land-use change is primarily driven either by population change or land management. As the population grows, more land is required to supply food and, in some cases, fuel wood. While demand for food grows, the land's ability to meet that demand may increase or decrease depending on changes in productivity and project activities.

The model was constructed with three principal considerations:

* To capture the essential physical interactions between people and forests in developing countries.
* Simplicity.
* To represent a wide variety of situations and management schemes.

The principal purpose of the model was to track the implications of different management schemes in widely different areas to evaluate project proposals. The model does not predict prices, incomes, or other economic indicators. The user must determine the rates of change for key parameters such as population and agricultural productivity. The model serves as an accounting tool, tracing the implications of these scenarios. Because the nature of the interventions proposed are often diverse (for example, agroforestry, fuel wood stoves, forest management, agricultural extension), and because the model was designed to operate at the project or sub-regional level, land use is the basis of the model. This places the burden of defining the future on the analyst, and not on the model.

The model structure is divided into the following categories: Population, Land Use and Biomass, Agricultural Production, Fuel wood, Forest Management and Uses, Forest Harvesting, and Project Management. For the purposes of this study, the last category was set to zero.

Population

Changes in land use are determined by population growth, agricultural productivity and its growth rate, and project activities. Since it is assumed that the local people derive most of their livelihood from the project region, increases in population increase demands on the landscape. As the population grows more land is required to supply food and fuel wood. However, while demand grows in absolute terms, its impact on the land base can grow at a lesser or even negative rate depending upon changes in productivity and other economic activities.

The *rate of population change* slows to zero as the year that the population is expected to stabilize approaches. In this way the model can represent a demographic transition from exponential growth to stability.

Land Use and Biomass

As the name implies, land use is the basis of the LUCS model. The nine categories of land represented in the model are based on principal uses and distinguished by the amount of biomass present. The biomass of each category is constant and represents the average amount of tons of biomass per hectare of that land use type. For example, the tons of biomass per hectare for mature closed forest is clearly not equal on each hectare, so an approximate average of the biomass for the area of closed forest should be used.

The model also represents changing biomass levels by movement from one land class to another. Forest degradation, for example, due to loss of biomass for any given cause, is represented as a movement of land from closed forest to open woodland and then to degraded land.

The principal land uses include:
*Three categories of agriculture: - permanent, shifting and agroforestry.
*Five categories of forest or woodland - closed, open woodland, tree plantation, forest fallow and restored forest.
*One category combining grazed and degraded land.

The five categories of forest (except for open woodland) are subdivided into early, medium, and mature age classes to represent growth stages in forest maturation. Biomass accumulation in tree plantations, restored forests, closed forest, and forest fallow is represented by "aging chains."

Carbon in standing biomass is determined by multiplying the area of each land use category by its average biomass on a per unit area basis then multiplying the sum by the carbon content of biomass.

Agricultural Production

Required agricultural land is a function of *population*, *agricultural land required per person*, *fraction of food imported,* and agricultural land required for export production. Agricultural land per person is a variable that captures the productivity of the project region. Areas of low productivity require more agricultural land to support the population and export production. The value of this variable changes over time according to the estimate given for *growth rate in agricultural productivity*.

Agricultural land requirements are reduced by the *fraction of food imported* into the project area and increased by the amount of *land used for export production* and its rate of growth.

There are three broad types of agriculture specified in the LUCS model: permanent, agroforestry, and shifting agriculture. This disaggregation is necessary to capture principal differences in cropping, fuelwood production, associated land use, and average biomass. Permanent agricultural land as used here can be thought of as continuously cropped land. Agroforestry is another type of permanent cropping, but these systems, in some cases, can be mixed with perennials and commodities produced may include a crop used as fuel and typically have a greater amount of biomass. Shifting agricultural land is not continuously cropped, but rather is put into fallow after some period of cultivation. At the end of the fallow period the land is either returned to cultivation, or eventually returns to forest.

Each of these three categories of agricultural land is characterized by its own level of productivity. In the LUCS model, productivity is defined as the amount of land required to support one person. More productive systems of production can support more people on a given unit of land. The productivity of agroforestry and shifting agriculture should be defined in relation to permanent agriculture. For example, in a project that helped set up community nurseries to encourage agroforestry, the project developers estimated that agroforestry was one and one half times more productive than permanent agriculture. Therefore the variable, *ratio of productivity of agroforestry to permanent agriculture*, would equal 1.5.

In order to determine if the amount of agricultural land at any given time is sufficient to meet local and export requirements, the model multiplies the area of each category by its respective productivity ratio (1 for permanent agriculture). These are summed to determine the total amount of agricultural land, which is compared to the required agricultural land to determine the *agricultural land shortfall*. Required agricultural land is estimated one year in advance, so there will be a shortfall as long as population is growing.

An agricultural land shortfall results in the movement of land to agriculture. Land can be moved to agriculture from: 1) conversion of closed forest, 2) conversion of open woodland, and 3) reversion of forest fallow. The rate of conversion is indicated by the relative amounts of open woodland and closed forest, the agricultural land shortfall, and the fraction of new land brought into permanent agriculture. Limits are placed on the conversion, as no more open woodland can be converted than exists, and no more land can be put into permanent agriculture than is suitable for that type of production (*maximum permanent agricultural land*). The time required to convert agricultural land is assumed to be one year in order to match projected with actual requirements.

More details of LUCS Model are presented in the 2002 Interim Report (Winrock International 2002).

Calakmul Region in Campeche.

The state of Campeche is located in Southeastern Mexico, at latitude 17° 49' 01" to 20° 51' 37" N and longitude 89° 05' 20" to 92° 28' 21"° W (Maps 3 and 4). It adjoins the state of Yucatán at the north, Tabasco and Guatemala Republic at the south, the state of Quintana Roo and Belize at the east, and the Gulf of México and part of Tabasco at the west. Campeche occupies a strategic position in the western part of Península de Yucatán.

Map 3: Campeche and Mexican Republic
(Gobierno del estado de Campeche)

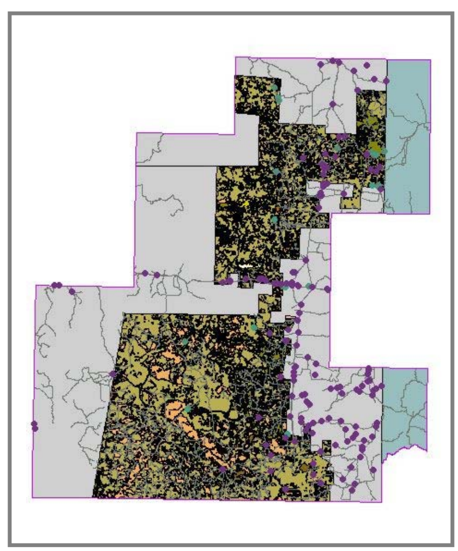
The Calakmul area is located in the Southeastern region of the state of Campeche, bordering Guatemala and Belize at south, and the State of Quintana Roo at East (Map 4).

Map 4: Municipalities of Campeche State
(Gobierno del estado de Campeche)

Calakmul Municipio covers an area of 1,383,911 hectares, embracing the 723,185 hectares (1.8 million acre) Calakmul Biosphere Reserve; one of the largest protected areas in Mexico which forms part of the 2.2 million hectares (5.5 million acre) tri-national complex of protected areas known as the Maya Forest. This natural treasure contains the largest intact tropical and subtropical forest ecosystems outside of the Amazon Basin. Once the center of the ancient Maya civilization, today the ruins of pyramids rise above the forest canopy where one can behold unbroken tropical forest stretching to the horizon in all directions.

Calakmul Reserva is formed by two core or nucleus zones: one at the north with 147,915 Ha and the other at south with 100,345 Ha., for a total of 248,260 Ha.; and a buffer zone of 474,924 Ha.

Studied area includes 1,329,280.75 part of which are permanent water bodies (9,587.72 Ha, about 7 % of the area) and 955.61 Ha with no land use data. Thus the studied focused on lands with changing use with available data: 1,318,737 Ha formed by 0.64 % under pasture and agriculture, 1.2% of savanna, 2.49 % with secondary vegetation and 95.6 % of the land with different types of selva (alta, baja, and mediana).



Calkmul Biosphere Reserve
(by courtesy of Myrna Hall)

Modeling Assumptions:

***Population*:**

In many regards, Calakmul is one of the last frontiers in Mexico. The area is lightly populated and offers an abundance of land for agricultural purposes. In past decades, Calakmul region lured many from various regions in central and south Mexico, looking for land and opportunity. Recent census data reveals that Calakmul is home to immigrants from 26 of Mexico's 32 states (Swanson, Grant; 1999). With this mixture, Calakmul has become a microcosm of Mexico. However, this melting pot in the jungle sometimes creates tension between immigrant groups. New arrivals also brought agricultural practices from their homelands that were often not compatible with the ecosystems and climate in Calakmul, thus agriculture and cultivated pasture yields were, in many cases, much less than expected, resulting in wide forest clearing areas to obtain enough production but, in other few cases, abandonment of agriculture or grazing activities.

Because of this, determining population growth trends represents a big challenge, as population dynamics is quiet complex and variable. From a first sight, Calakmul's appeal is fueling a regional annual growth rate of 4%, which would cause the region's population to double in 20 years if the same trend continues (Ericson, J. 1999). Alarming growth rates have been recorded in "hot spot" communities. For example, between 1990 and 1995 the ejido 11 de Mayo grew 23% annually, more than tripling in size in just 5 years. Similar growth is affecting other communities located along the east-west highway that bisects the reserve.

On the other hand, from analysis of INEGI (National Institute of Statistics, Geography and Informatics) census data, we can observe communities showing high declining rates of population growth and even others with fluctuant or net decrease in absolute numbers, such as Emiliano Zapata (fluctuating from 158 inhabitants in 1980 to 64 in 1990, then 40 in 1995 and finally 112 in year 2000).

One more difficulty is the availability of municipal level information. The municipality of Calakmul was created in 1997, thus there is no previous census information at this level and we had to compile the data from community level. To deal with this problem we resorted to more detailed sources of information.

Our main sources of data for population were year 2000 census from INEGI and a very comprehensive paper from the American Association for the Advancement of Science which, based on INEGI information, provides population data for years 1980, 1990 and 1995 for existing communities, both within the Calakmul Municipality and around. (see more detail in Annex IIII)

For the communities within the new municipio of Calakmul, these sources reveal a very high annual population growth rate between 1980 and 1990 (11%), abruptly declining to 4.9% from 1990 to1995 and finally slowing to 4.6% between 1995 and 2000 (Annex III).

Regarding communities bordering the Calakmul municipality, changes in annual growth rates are more abrupt: 12.2 % for 1980-90 period, 4.8% between 1990 and 95, and 1.69% from 1995 to 2000 (Annex III).

From a regional perspective considering both communities within Calakmul municipality and bordering communities, growth rates are: 11.25% (1980-95), 4.9 (1990-95) and 4.04% (1995-2000).

It is hard to explain the abrupt change from 80's to 90's. One possible explanation is that there are few available 1980 data for most communities as many of them were settled in Calakmul by late 70's and early 80's and even some between 1990 and 1995. Thus it might be that we are missing data. On the other hand, land distribution and allocation was declared finalized by 1992 and subsidies as well as other different types of support for agriculture and peasants were significantly reduced in the last decade. The attractiveness of Calakmul region is now concentrated in few points, where tourism may be an opportunity.

There is also lack of information about growth of population occupied in the primary sector. The only data we got from INEGI corresponded to 2000. For this year, the population occupied in primary activities (the fraction driving land use change) represented 73.56%. No information was available for past decades, though it was surely higher.

For all the reasons mentioned above, we assumed population growth rate will keep declining for the next 20 years at the same proportion it did from 1995 to 2000. In other words, it will finally stabilize to 0 in year 2020.

We are assuming also an initial population of 17,000 inhabitants, 73.5% of the total present population of Calakmul municipality (23,115 inhabitants).

Summarizing, the following values were set for the Population section variables:

Initial Population:	17,000
Initial Annual Pop. Increase rate (2000):	4.0 %
Year Population will stabilize:	20
Aver. Family size	5.19 persons

Land Use and Biomass

Based on imagery analyses from Myrna Hall, we set the following initial land-use areas for year 2000. No disaggregated information was found to separate initial forest and fallow land by aging categories, thus we assumed all the Close Forest (Selva) as mature (aging category 3) and let LUCS model to calculate areas for each aging category of fallow land and secondary forest.

Forest (Selvas Alta, Mediana y Baja)	1,261,641 Ha.
Secondary Forest (calculated old acahual)	11,671 Ha.
Fallow land (secondary vegetation)	21,120Ha.
Aging cat. 1(calculated by LUCS)	7,040 Ha.
Aging cat. 2 (calculated by LUCS)	7,040 Ha.
Aging cat. 3 (calculated by LUCS)	7,040 Ha.
Shifting agriculture	8,449 Ha.
Grazed land (Savanna)	15,856 Ha.
Total area	**1,318,737 Ha.**

Based on previous studies (Morales, J. 1997; Ruiz, F. 1999; Brown, S. 1999) and data from Ben De Jong (Colegio de la Frontera Sur) on biomass estimations for the studied area, we set the following standing biomass and carbon values. Selva's biomass represents a weighted average for Selva Baja, Mediana and Alta:

Biomass accumulation in secondary forests after clearing is based on Read, L. and D. Lawrence, 2003 (including Brown, S. estimates of roots at 20% of aboveground). Suggested increments for this region is 1.9 t C/ha/yr (3.8 tons of biomass/ha/yr) for young re-growing forests. De Jong estimated values as well as mentioned previous studies revealing an average biomass of 69 ton/ha for acahuales (secondary vegetation) 10 to 12 years old.

	Biomass (ton/Ha)	Carbon (Ton/Ha)
Closed Forest (Selvas weighted average)	115	57.5
Secondary forest (old acahual)	69	34.5
Fallow land: cat 3	37.0	18.5
cat. 2	30.6	15.3
cat. 1	24.3	12.15
Shifting Agriculture land	18	9
Grazed land (Savanna)	29	14.5

Agricultural Production

According to Ericson J. (1999) "although most of the farmers in the region's economically marginalized communities practice subsistence and small-scale agriculture, migrants from central and northern Mexico have a propensity to employ mechanized agriculture and agrochemicals for cash crop cultivation. These farming technologies contributed to the reduction in forest cover as well as declines in soil fertility and structure of this tropical ecosystem. In contrast, colonists already familiar with the tropical forest of the Yucatán Peninsula, such as the indigenous Maya, use the swidden system of agriculture that allows the forest to regenerate. Regeneration of secondary growth during the fallow period is encouraged by the Mayan populations because various forest products have use and exchange values. In both systems, the use of fire to clear brush and crop residue before the onset of the rainy season can be sorely destructive. Unless supervised by experienced farmers familiar with the ecosystem, fires burn quickly out of control".

However, the attempts toward mechanized agriculture and cattle ranching are currently highly constrained by financial and ecological restrictions. Both activities require a financial investment greater than that available to the majority of the region's colonists. In some communities, poor soil conditions and a shortage of permanent water sources prohibit both these activities.

Some conservation/management programs have been initialized in the various communities; focused on stabilizing land-use and curbing the expansion of agricultural and pasture lands by improving incomes from forestry-based enterprises such as sustained-yield timber harvesting, chicle extraction, apiculture, and agroforestry. However, it is uncertain that increased income generation from forest product extraction will reduce the amount of land in agriculture without effective land-use planning.

Regarding cultivation and fallow periods for shifting agriculture, previous visits to the area as well as interviews with ejidatarios, NGO promoters and researchers from PPY and Universidad de Campeche, revealed that lands are currently cultivated for an average of 2 years (varying from 1 to 3 or 4 years) and then put into fallow during a 5 year average period (varying from 4 to 8), although this fallow period used to be longer in the past (up to 10 to 12 years).

Interviews also revealed that cattle ranching is declining, due to frustration on yields for this activity, causing abandonment of pasture lands which are being invaded, in many cases by an invasive fern species which prevents regeneration of acahuales (secondary vegetation). Unfortunately we have no data about the amount of hectares subject to this abandon/invasion process.

Based on comments above, we have set values for agriculture land, fallow and productive periods, as follows:

Agriculture land (includes pasture land):		
	Shifting	8,449 Ha.
	Permanent	0 Ha
Fallow period:		5
Productive period (constant):		2
Years required for forest fallow to revert to selva biomass		50

Forest system and Wood extraction

According to national forestry law, forestry studies and management plans are required to receive permission from the federal government for cutting authorized volumes of specified forest tree species in designated locations. This law establishes the prohibition of unauthorized timber exploitation on *ejido* lands and the complete prohibition within the core zone of the reserve.

However, survival strategy pressures play themselves out in the illegal trade for tropical hardwoods. According to Ericson J., "illegal extraction of precious and other marketable hardwoods occurs from individual *parcelas (plots)* and communally managed forest areas on *ejido* lands. Illegal timber cutting also occurs within the core area of the reserve and along both sides of the border shared with Guatemala. Both the *ejidos* and the reserve management staff lack an effective enforcement system to control this extraction. Enforcement structures are difficult to build when demand for precious hardwoods is high". According to personal communications, some of the timber is sold within the Calakmul region, but most of it is purchased by distributors from outside the region.

On the other hand, many *ejidos* have gone into legal extraction since the early nineties, lured by attractive regional forestry programs driven by governmental and non governmental institutions, both national and international, such as "Bosque Modelo", PRONATURA Península de Yucatán, (PPY), Trópica Rural Latinoamericana, and Plan Piloto Forestal (in Quintana Roo state), among others.

We have no precise information about the amount of forest hectares currently under management, but interviews with regional foresters, ejido authorities and NGO's, reveal that most of the larger ejidos have entered into this regime. Thus we may assume that more than a half of the area outside the core zone is being managed in some sustainable degree.

Data from the Programa de Certificación de Derechos Ejidales (PROCEDE) reveal that of a total of 63 ejidos in Calakmul municipality, 59 of them cover an area of 144,257 hectares of declared forest use outside the core zones, from which 143,026 Ha (99%) are under a forest common use regime.

To gain an idea of the area under forest management and amounts of legal wood extraction, forest management plans from 3 large ejidos (Nuevo Bécal, Zoh Laguna, and Conhuas) were reviewed. From these documents we observed a very low amount of extraction (from 1 to 5 m^3/Ha) under a 25 year cutting cycle. That is 1/25 of the forest under common use is being harvested on a yearly basis.

Extrapolating these data we might conclude that less than 6,000 Ha. of forest are legally harvested every year, assuming all the 59 ejidos were allowed to extract wood from their common use forests. For purposes of this study we assumed 5,000 Ha/year are harvested under management practices, thus with very low impact on forest biomass (15%), plus 1,000 Ha/year illegally harvested, with slightly higher impact (30%). To compensate possible underestimates on illegal harvesting we set a 20 year (instead of 25) period for harvested forest to revert to non harvested forest biomass.

Effectively protected forests were set to 248,260 Ha. (the area of both core zones).

Regarding human caused fire incidence, this variable does not seem to be a major threat to the Selva, as natural recovery of vegetation proceeds faster than fire degradation. Data from 1995 to 1999 reveal an average of less than 800 Ha. Burned per year for the whole Calakmul region (less than 0.1% of Selva within Calakmul municipality). Based on this assumption, values for degradation from forest to open woodland were set to zero.

A summary of all assumptions for forest system appears in the following Table:

Forestry system

Hectares of managed forest harvested in a yearly basis	5,000 Ha.
Fraction of forest biomass extracted or damaged during harvest (from aging cat. 3 to cat. 2)	15%
Hectares of unmanaged forest harvested in a yearly basis	1,000 Ha.
Fraction of forest biomass extracted or damaged during harvest(from aging cat. 3 to cat. 1)	30%
Years required for forest cat. 1 to revert to forest cat. 2 biomass	20
Years required for forest cat. 2 to revert to forest cat. 3 biomass	20
Number of hectares of forest effectively protected	248,260
Number of hectares of forest degraded to open woodland	0

Fuel wood use and requirements:

According to INEGI census for year 2000, more than 86% of the families in Calakmul municipality use fuel wood for cooking. Taking into consideration that 76% of total population is rural, we may assume that 100% of the rural population uses fuelwood.

Although this could be seen as a very high demand, fuel wood availability far exceeds the requirements if we take into account that every family converts at least one hectare of forest per year to agriculture.

Based on personal communications from previous studies in the region as well as on requirements from similar regions we set fuelwood consumption per person variable to 2 tons/year, or 10.38 tons/family/year.

Modeling Results and Discussion

The simulated process of land use change showed a total deforestation (increase of agriculture land) of 3,664 ha during a 20 year period (after which population stabilizes) which, assuming constant values for forest and agriculture biomass, represents net carbon emissions of some 375,000 Carbon Tons. For a 30 year period, once secondary forest begins to recover to selva, net deforestation increases to 3,899 Ha but net carbon emissions decreases to 365,000 carbon tons. Land use change process results are as follows:

	LAND USE (HA)								
YEAR	SELVA	SAVANNA	(FALLOW LAND)				SEC. FOREST	SHIFTING AGR.	TOTAL
			CAT 1	CAT 2	CAT 3	SUB TOTAL			(HA)
2000	1,261,641	15,856	7,040	7,040	7,040	21,120	11,671	8,449	**1,318,737**
2001	1,261,526	15,698	7092	7,045	7,040	21,177	11,600	8,736	**1,318,737**
2002	1,261,346	15,541	7,221	7,092	7,050	21,363	11,521	8,966	**1,318,737**
2003	1,261,069	15,386	7,379	7,185	7,088	21,652	11,441	9,189	**1,318,737**
2004	1,260,705	15,233	7,550	7,312	7,159	22,021	11,361	9,417	**1,318,737**
2005	1,260,269	15,081	7,732	7,463	7,262	22,457	11,280	9,650	**1,318,737**
2010	1,257,589	14,345	8,690	8,373	8,064	25,127	10,874	10,802	**1,318,737**
2020	1,253,990	12,978	10,002	9,868	9,691	29,561	10,095	12,113	**1,318,737**
2030	1,254,534	11,742	10,273	10,250	10,217	30,740	9,373	12,348	**1,318,737**

More detail on population and of land use change process in a yearly basis can be observed in Annex I.

A significant limitation of LUCS model lies in its inability to model different types of vegetation (in this case Selvas Alta, Mediana and Baja) in a separate way. Thus we can not quantify the amounts of each type of forest under deforestation process nor the conversion from one type of vegetation to others.

However, compared to historical process of deforestation in the Calakmul municipio, LUCS results coincide relatively well with values for the 1995-2000 period when, although selvas alta and mediana decreased approximately 22% (from 903 thousand in 1995 to 705 thousand hectares in 2000), selva baja increased more than 100% (from 208 thousand to 422 thousand hectares). Considering all types of selva together we observe no deforestation process in this 1995-2000 period, but rather a slight process of natural recovering of forests. Same results can be observed from a regional perspective (beyond Calakmul municipality boundaries).

Even though from 1970 to 1995 a net deforestation process took place in the area where Calakmul municipality is located, the current process of low to no deforestation may be explained with same arguments as those given in the assumptions section.

To have an idea of present modeling uncertainties, an analysis of sensitivity was made by changing values in some variables such as annual growth rate of population and illegal cutting of forest.

While setting the year in which population stabilizes to 2029 (instead of 2019), deforestation amounts increase 1.5 times (from 7,651 ha of lost selva to 11,843 Ha.) for year 2020. Going farther to year 2030, deforested area increases more than double. The growth rate of population is then, a key variable that must be better analyzed.

On the other hand, increasing annual illegal harvest in the forest to 5,000 Ha. (instead of 1,000), assuming also 500 persons are sustained solely by incomes from wood-selling instead of agriculture, deforested area decreases by more than 10% for year 2020. Thus we may conclude that illegal harvesting is not a major threat to forest at this level, although average forest biomass diminishes by a small amount.

Results are presented in the following tables:

CALAKMUL MUNICIPALITY: RESULTS FROM LUCS MODEL (sensitivity analysis)

CALAK1

YEAR	POPULATION		LAND USE (HA)								TOTAL	selva
			SELVA	SAVANNA	FOREST FALLOW LAND				SECOND. FOREST	SHIFTING AGR.		biomass
	Inhabi-tants	growth rate			CAT 1	CAT 2	CAT 3	SUB TOTAL			(HA)	(ton/ha)
2000	17,000	4.00%	1,261,641	15,856	7,040	7,040	7,040	21,120	11,671	8,449	**1,318,737**	115.00
2020	24,951	0.00%	1,253,990	12,978	10,002	9,868	9,691	29,561	10,095	12,113	**1,318,737**	114.18
2030	24,951	0.00%	1,254,534	11,742	10,273	10,250	10,217	30,740	9,373	12,348	**1,318,737**	113.97
2020-2000	**7,951**		**-7,651**	**-2,878**	**2,962**	**2,828**	**2,651**	**8,441**	**-1,576**	**3,664**	**0**	
2030-2000	**7,951**		**-7,107**	**-4,114**	**3,233**	**3,210**	**3,177**	**9,620**	**-2,298**	**3,899**	**0**	

CALAK2: YEAR POP. STABILIZES=30

YEAR	POBLACION		LAND USE (HA)								TOTAL	selva
			SELVA	SAVANNA	FOREST FALLOW LAND				SECOND. FOREST	SHIFTING AGR.		biomass
	Inhabi-tants	growth rate			CAT 1	CAT 2	CAT 3	SUB TOTAL			(HA)	(ton/ha)
2000	17,000	4.00%	1,261,641	15,856	7,040	7,040	7,040	21,120	11,671	8,449	**1,318,737**	115.00
2020	28,757	1.24%	1,249,798	12,978	11,083	10,749	10,395	32,227	10,064	13,670	**1,318,737**	114.18
2030	30,455	0.00%	1,246,284	11,742	12,309	12,187	12,024	36,520	9,319	14,872	**1,318,737**	113.97
2020-2000	**11,757**		**-11,843**	**-2,878**	**4,043**	**3,709**	**3,355**	**11,107**	**-1,607**	**5,221**	**0**	
2030-2000	**13,455**		**-15,357**	**-4,114**	**5,269**	**5,147**	**4,984**	**15,400**	**-2,352**	**6,423**	**0**	

CALAKMUL MUNICIPALITY: RESULTS FROM LUCS MODEL
(sensitivity analysis)

CALAK1

YEAR	POPULATION		LAND USE (HA)									
					FOREST FALLOW LAND						**TOTAL**	selva
	Inhabi-tants	growth rate	SELVA	SAVANNA	CAT 1	CAT 2	CAT 3	SUB TOTAL	SECOND. FOREST	SHIFTING AGR.	**(HA)**	biomass (ton/ha)
2000	17,000	4.00%	1,261,641	15,856	7,040	7,040	7,040	21,120	11,671	8,449	**1,318,737**	115.00
2020	24,951	0.00%	1,253,990	12,978	10,002	9,868	9,691	29,561	10,095	12,113	**1,318,737**	114.18
2030	24,951	0.00%	1,254,534	11,742	10,273	10,250	10,217	30,740	9,373	12,348	**1,318,737**	113.97
2020-2000	**7,951**		**-7,651**	**-2,878**	**2,962**	**2,828**	**2,651**	**8,441**	**-1,576**	**3,664**	**0**	
2030-2000	**7,951**		**-7,107**	**-4,114**	**3,233**	**3,210**	**3,177**	**9,620**	**-2,298**	**3,899**	**0**	

CALAK3: Selective cutting without management= 5,000 Ha

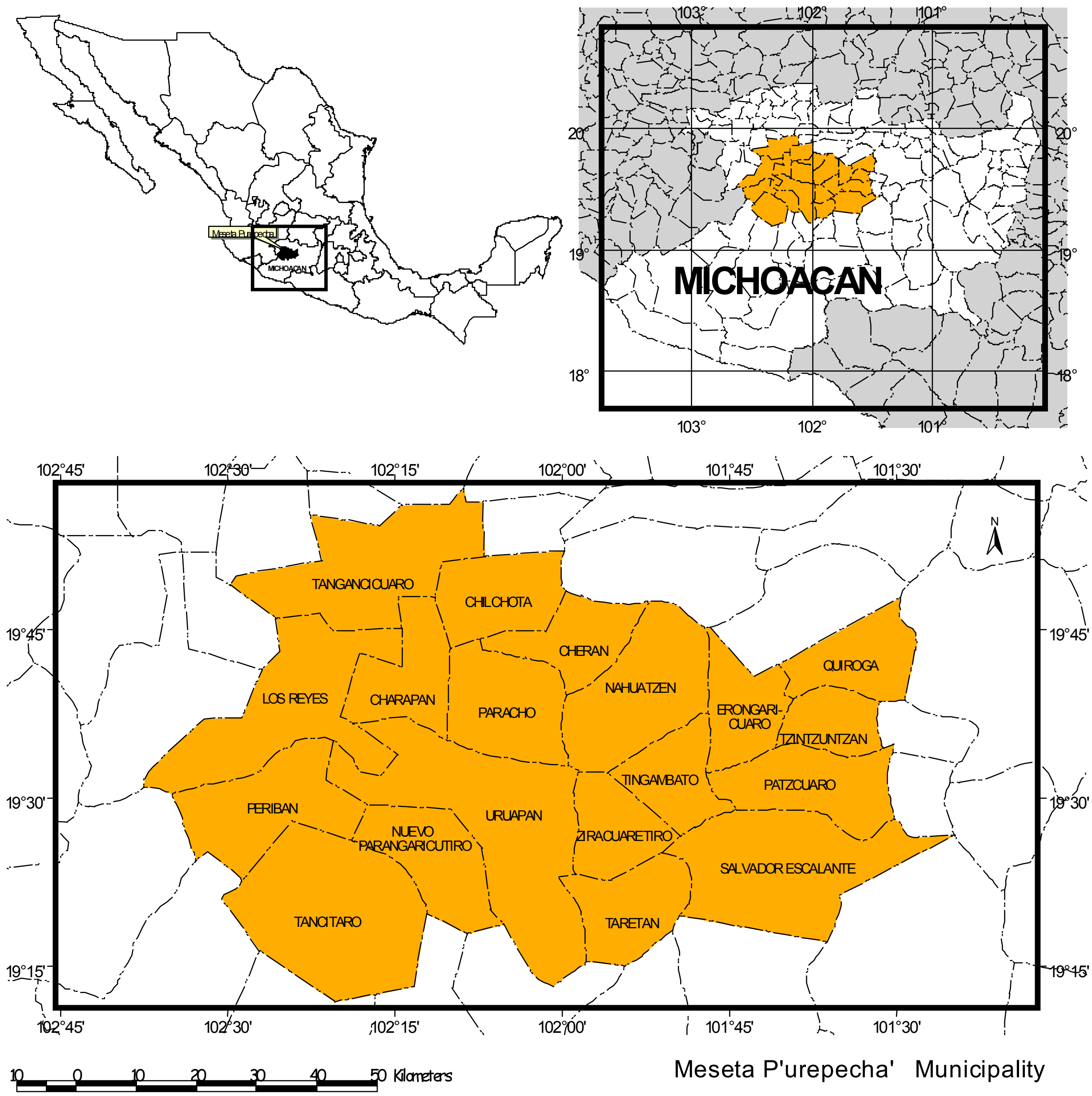
Persons sustained by forest harvesting= 0.1/Ha.

YEAR	POBLACION		LAND USE (HA)									
					FOREST FALLOW LAND						**TOTAL**	selva
	Inhabi-tants	growth rate	SELVA	SAVANNA	CAT 1	CAT 2	CAT 3	SUB TOTAL	SECOND. FOREST	SHIFTING AGR.	**(HA)**	biomass (ton/ha)
2000	17,000	4.00%	1,261,641	15,856	7,040	7,040	7,040	21,120	11,671	8,449	**1,318,737**	115.00
2020	24,951	0.00%	1,254,825	12,978	9,801	9,669	9,494	28,964	10,101	11,869	**1,318,737**	113.11
2030	24,951	0.00%	1,255,394	11,742	10,067	10,044	10,012	30,123	9,378	12,100	**1,318,737**	112.58
2020-2000	**7,951**		**-6,816**	**-2,878**	**2,761**	**2,629**	**2,454**	**7,844**	**-1,570**	**3,420**	**0**	
2030-2000	**7,951**		**-6,247**	**-4,114**	**3,027**	**3,004**	**2,972**	**9,003**	**-2,293**	**3,651**	**0**	

Meseta Purépecha Region in Michoacán.

The State of Michoacán is located in the central western region of Mexico approximately at latitude 18.0° N to 20.5° N and longitude 100.0° W to 104.0° W (Map 1).

The Meseta Purépecha is located in the central region of Michoacán (latitude 19°14’ N to 20° N and longitude 101° 30’ W to 102° 45’ W) and is formed by the following 19 municipios: Charapan, Cheran, Chilchota, Erongaricuaro, Nahuatzen, Nuevo Parangaricutiro, Paracho, Patzcuaro, Periban, Quiroga, Los Reyes, Salvador Escalante, Tancitaro, Tangancicuaro, Taretan, Tingambato, Tzintzuntzan, Uruapan, Ziracuaretiro (Map 1).



Modeling Assumptions:

The Meseta Purépecha area has been subject to logging activities for the last 50 years, with forest degradation and conversion of forest to subsistence and commercial agriculture, namely avocado, for the last 20 years. These types of activities are predicted to threaten the forest within the study area for the next 20 years in a business as usual scenario.

We developed a baseline for this region using the LUCS model, which takes into consideration the interactions between population and land use change.

In acquiring the necessary data for land use and biomass as well as for some socio-economic and technological information, we received help from people working at the Instituto de Ecología UNAM and GIRA (an NGO based in Patzcuaro). As much existing data as possible was acquired, with an emphasis on land-use change dynamics and fuel wood consumption.

Population:

Based on data from the INEGI 2000 census as well as on personal estimates for rural population (tables presented in annex IV), we defined input values as follows:

Initial Population (inhabitants):	160,628
Initial Annual Pop. Increase rate (1992):	1.70 %
Year Population will stabilize:	2026
Aver. Family size:	4.52

Initial population represents 21% of present population in the studied area. Annual growth rates are based on data from CONAPO 1995-2010 projections.

Land Use and Biomass

Inputs for land use and biomass data were provided by Omar Masera (based on satellite imagery analysis) and Jaime Navia (based on 2000 Forest Inventory data).

	Area (Ha)	**Biomass (Ton/Ha)**
Total within the studied area boundaries	**602,291**	
Closed Forest (aging cat's 1-3)	**218,286**	
Cat. 1 (classes 2 & 3)	167,015	62.18
Cat. 2: (classes 4 & 5)	50,843	137.61
Cat. 3: (class 5 maximum)	428	225.00
Opened Woodland	**30,427**	15.18
Restored Forest	**1,034**	60.00
Agroforestry (Avocado)	**52,000**	60.00
Permanent agriculture	**162,535**	10.00
Degraded or grazed land	**138,009**	15.00

To estimate area and biomass for different forest classes and degraded land, we used 2000 forest inventory data provided by Navia (Existencias Forestales Meseta Purépecha). Standing biomass was calculated from wood volume.

Avocado plantations are one of the biggest threats to forest cover. However, recent high rates of increase make it difficult to obtain precise data about its current area. As a result, various contrasting sources were consulted to define agroforestry (avocado) area:

From satellite imagery analysis, Masera provides an area of 32,410 ha. covered by avocado and other fruit trees for year 2000. However, other authors mention a larger area for previous years: Bocco, based on avocado census information from SAGAR, sets the area covered by avocado in 5 municipalities within the Meseta Purépecha to 39,849 Ha. for year 1993, while Coria and Martínez, from interpretation of 1991 aerial photographs, obtain a total of 41,957 Ha. for the Meseta Purépecha (62,393 for the state of Michoacán). These authors are currently developing a new GIS study and have suggested (in personal communications) that current avocado area must be about 100 thousand hectares in Michoacán. Finally, the most recent study from Anguiano C. José (2001) establishes that avocado area in 2000 is up to 78,176 for the whole state.

This latest source was the one we selected for the simulation. Thus, considering that Meseta Purépecha represents 67% of the avocado area in the whole state of Michoacán, we set the agroforestry area to 52,000 Ha.

Restored forest and agriculture land areas were based on Masera's data. Area under agriculture was increased slightly (from 140,000 Ha. to 162,535) to meet the INEGI and forest inventory-reported total area.

Values for avocado, degraded land, and agriculture biomass are based on personal estimates from previous studies.

Area and biomass values of the remaining land use categories used by LUCS, were set to zero.

Wood Products and Fuel wood Use Parameters

According to Masera et al (1998), domestic fuelwood consumption in the region is 2 kg/person/day (1.2 m3/person/year), thus, for the total rural population (160,628), consumption would reach 117.26 thousand tons/year.

However, these authors reveal that "besides domestic consumption, fuelwood is also used for urban families and for industrial purposes", thus regional fuelwood consumption would be as follows:

- - domestic use fuel wood : 267,475 m3/year (including urban families)
- - fuelwood for panaderías (bakeries): 6,543 m3/year
- - fuelwood for tabiqueras (brick factories): 98,175 m3/year
- - fuelwood for alfares (potter workshops): 64,084 m3/year

Adding previous amounts, total fuelwood consumption equals 437,267 m3/year, which, considering a ratio of 0.6 ton/m3, represents 262,360.2 ton/year. For LUCS modeling purposes, we must set annual fuelwood requirement to an individual level (ton/person). Dividing this number by the rural population yields 1.63333 ton/year.

According to Masera (op. cit. Page 57) most wood used for domestic fuel purposes is represented by oak (*Quercus spp*). Thus, to obtain the fraction of wood available for fuel wood from closed forest conversion to agriculture, we estimated the percentage of wood stock that corresponds to oak species which, according to Navia tables represents 22.96%. From the remaining 77%, about one third is destined to permanent uses and two thirds for use as fuel for industrial purposes. In the case of open woodland conversion, we set this value to 1, as most of this forest category is 100% oak.

To set the fraction of wood for permanent uses we considered that a normal forest harvesting intervention extracts about 75.43 tons of biomass (difference between CF2 and CF1). From this amount 70% is represented by commercial species (aserrables), and from this amount only 70% of the whole tree is destined to sawmills, where 50% is transformed to lumber. In other words only 18.5 tons/ha are transformed to wood products for permanent uses, or 13.4% of the average biomass of forest aging category 2 (CF2).

Fuel wood requirement (metric tons/person/year)	1.63
Fraction of wood available for fuel wood (from conversion of Closed Forest and).	0.74

Fraction of wood available for fuel wood (from conversion of Open Woodland)	1.0
Fraction of wood for permanent uses (from: Closed Forest)	0.13
Predominant use of wood products	Lumber
Useful life of wood products	20 years

Forest system:

According to forest inventory data on annual increments of different forest classes, time required for one forest land use category to meet next class biomass is as follows:

Maturation time	
Years required for Closed Forest cat.1 to revert to Closed Forest cat. 2 biomass.	24
Years required for Closed Forest cat.2 to revert to Closed Forest cat. 3 biomass	12.2
Years required for degraded land to revert to Open Woodland biomass if left alone	30
Years required for open woodland to revert to Closed Forest biomass if left alone	100
Years required for degraded land to revert to Closed Forest biomass if left alone	100
Maturation time for restored forest	80

Details on calculations can be seen in Annex V.

The only recent data regarding the forest area harvested on a yearly basis was from Masera and Navia (op. cit. page 71) for years 1994-1996. During this period, legally area harvested varied from 2,230 Ha. in 1994 to 5,263 in 1995 and 3,075 ha in 1996. However, from personal communications which suggest that illegal harvesting doubles the authorized amount of wood extracted, and based on wood demand for the region (Masera and Navia, op. cit.), we assumed a total of 15,000 Ha. annually harvested.

The fraction of biomass damaged during harvest was obtained from forest inventory data.

Number of hectares of closed forest harvested in a yearly basis (ha/year)	15,000
Fraction of Closed forest biomass extracted or damaged during harvest (%)	0.55

Agriculture system:

As we have mentioned above, avocado area growing rate is one of the most critical drivers in land use change. From Masera's anlysis we can observe that during 1995-2000 period, agriculture land (including avocado) increased 23,820 ha. of which 53% correspond to avocado (12,653 Ha.) and 47% to annual crops (11,167 Ha). This source also reveals that 18,355 ha. of the total annual crops are irrigated, thus most of it has to be considered as commercial agriculture, which added to avocado area represents 70,000 ha. with annual increments of 3.6% for the same 1995-2000 period.

From personal experience and communications from farmers in the region studied, we know that avocado provides double the income than traditional annual crops. Thus, for LUCS modeling purposes, ratio of productivity of agroforestry to traditional agriculture was established as 2 to 1.

Comparing commercial and traditional agriculture (area and productivity) we conclude that 29% of population incomes rely on economic activities different from self subsistence agriculture.

Ratio of productivity of agroforestry to permanent agriculture (Number of persons sustained by one hectare of each type):	
Permanent agriculture (persons/ha)	1
Agro forestry (persons/ha)	2
Initial fraction of land converted to permanent agriculture	0.47
Initial fraction of land converted to agroforestry (avocado)	0.53
Initial agriculture land for export production (Hectares)	70,000
Growth rate of Agriculture land for export production (percentage/year)	3.6
Fraction of food imported (%)	29

The complete set of assumptions is provided in Annex VI.

Modeling Results and Discussion

Simulated process of land use change, shows a total deforestation of 80,756 ha during a 30 year period which, assuming constant values for grazed land, open woodland, agroforestry and agriculture biomass, and changing values for closed and restored forest, represent net carbon emissions of 381,515 Carbon Tons as follows:

	LAND USE (Ha)							**CLOSED FOREST AVERAGE BIOMASS (TON/HA)**	**CARBON (TON)**
YEAR	**PERM. AGRIC.**	**AGRO FOREST (AVOCADO)**	**CLOSED FOREST**	**OPEN WOOD LAND**	**REST. FOREST**	**GRAZED LAND**	**TOTAL AREA**		
2000	162,535	52,000	218,286	30,427	1,034	138,009	603,325	80.02	12,403,326
2001	162,954	52,473	217,221	16,196	1,034	152,413	603,325	81.98	12,591,074
2002	164,462	54,173	214,212	13,128	1,034	155,282	603,325	83.54	12,692,782
2003	166,155	56,082	210,858	12,286	1,034	155,876	603,325	84.96	12,767,394
2004	167,852	57,996	207,467	11,378	1,034	156,564	603,325	86.32	12,829,775
2005	169,525	59,882	204,082	10,226	1,034	157,542	603,325	87.63	12,882,048
2010	177,422	68,788	187,321	4,422	1,034	163,304	603,325	93.73	13,030,902
2015	184,406	76,664	171,345	2,171	1,034	166,671	603,325	99.15	13,031,839
2020	190,338	83,353	156,828	2,103	1,034	168,635	603,325	103.96	12,939,514
2030	196,452	90,247	137,530	2,591	1,034	174,437	603,325	112.01	12,784,841
	33,917	**38,247**	**-80,756**	**-27,836**	**0**	**36,428**	**0**		**381,515**

Details on annual basis and forest subcategories can be seen in Annex VII.

References:

Calakmul:

INE-SEMARNAP; Reserva de la Biósfera de Calakmul; Programa de Manejo, versión preliminar. 1998

Swanson, Grant and Andrea Erickson; The Nature Conservancy (TNC); Calakmul Climate Action Project, Preliminary version; 1999

Ericson, J., Mark S. Freudenberger and Eckart Boege; American Association for the Advancement of Science; Population Dynamics Migration and the Future of the Calakmul Biosphere reserve. Occasional paper No. 1, Summer 1999; Program on Population and Sustainable development (PSD)

INEGI; Pob. Campeche 1950-2000: Increase rate data in a 10-year basis at State level.

CONAPO; Pob. Campeche (proy 1995-2010): Pop. Projection 1995-2020 State level; 1995-2010 Municipal level (all the municipios of Campeche, Fig. 2)

INEGI; Sociodemografía Campeche 1990-2000; increase rate at municipal level for all the municipios in the state of Campeche.

INEGI; 2000 Population Census (CD-ROM)

Programa de Certificación de derechos Ejidales y Titulación de Solares PROCEDE 1992-2000. Campeche: Núcleos Agrarios, Tabulados Básicos por Municipio: tbe_camp: PDF file, very comprehensive document with information at municipal level, containing number and type of communities (ejidos, comunidades), area, land tenure for each community.

PROCEDE Ejidos y Comunidades 1991: Excel file with information at municipal level about land tenure, area, land use.

INEGI; Agricultura en Campeche: Excel file with information about agricultural production at state level, including main crops.

Brown, Sandra (Winrock International; Forest Carbon Monitoring Program); Mechanisms and measures for carbon emissions mitigation: feasibility studies for JI project advancement,Calakmul Biosphere Reserve, Mexico; June 28, 1999

Brown, S. 1997. Estimating biomass and biomass change of tropical forests: a primer. FAO Forestry Paper 134, the FAO, Rome, Italy.

Cairns, M., P. K. Haggerty, R. Alvarez, B. H. J. De Jong, and I. Olmstead. Tropical Mexico's recent land-use and land-cover change: a region's conribution to the global carbon cycle.

Sánchez, J. C., C. B. Salinas, C. M. Islas, J. E. B. Creel, and A. A. L. Viruel. 1996. Analisis cartográfico del cambio de uso del suelo en la Península de Yucatán, México. Amigos de Sian Ka''n A. C., Cancún, Quintana Roo, México.

Ruiz, Fernando (CONSEJO CIVIL MEXICANO PARA LA SILVICULTURA SOSTENIBLE, A.C.); Informe Técnico del Estudio de Pre-Factibilidad para el Proyecto de Acción Climática en Calakmul, Campeche; junio de 1999

INEGI; Campeche Geohydrological map

________________________ 1994 Programa de Manejo Forestal del Ejido Conhuás, Municipio de Champotón.

CONSEJO REGIONAL AGROSILVOAGROPECUARIO Y DE SERVICIOS DE XPUJIL, S.C., 1995. Programa de Manejo Forestal y Manifestación de Impacto Ambiental para el Ejido Nuevo Bécal, Municipio de Hopelchén Campeche; Zoh-Laguna, Campeche, MEXICO.

Read, L. and D. Lawrence, 2003. Recovery of biomass following shifting cultivation in dry tropical forests of the Yucatan. Ecological Applications, in press

Meseta de Purpécha:

A) Population:

INEGI; Población Michoacán 1950-2000.

CONAPO; Michoacan: Population. Projection (1995-2020 State level; 1995-2010 Municipal level, all the Michoacán municipios).

INEGI: Mich. Crec. Demografico 1895-2000 Pop. projection in a 10 year basis at state level.

INEGI; Mich. (municipios) 1990-2000. (increase rate at municipal level for all the municipios in the state of Michoacán).

INEGI;2000 Population Census (CD-ROM)

B) Fuelwood:

Masera, O.R. J. Navia (Coords), J.C. Cedeño, G. Ruíz and S. Ochoa. 1997. Consumo y Flujos de Leña en la Micro-región Lago de Pátzcuaro, Michoacán. Proyecto FAO/MEX/TCP/4553(A), Pátzcuaro, Michoacán, México. Mayo

Navia, Jaime; Fuelwood: fuelwood consumption (industrial and domestic) for the Meseta Purépecha. 2002 (personal comunication: 2 tables)

C) Land Tenure:

Programa de Certificación de derechos Ejidales y Titulación de Solares PROCEDE 1992-2000. Michoacán de Ocampo: Núcleos Agrarios, Tabulados Básicos por Municipio: tbe_mich: PDF file.

PROCEDE Ejidos y Comunidades 1991: Excel file with information at municipal level about land tenure, area, land use.

D) Forest:

Navia, Jaime; Existencias forestales: (Excel table based on data from 2000 Forest inventory about forest cover, wood stocks, forest classes, volumes, growth rate & erosion for the Meseta Purépecha at municipal level).

1995 Michoacán forest inventory (2 MS Word files inv_for_mich 2 and mich 3).

E) Land Use Change drivers:

Navia, Jaime; Avocado: Word document in spanish with historical data of area. Various sources.

INEGI; Agricultura en. Mich. 2000: Excel file with information about agricultural production at state level. Main crops.

INEGI; Unid. Prod. Rural 1991: Excel file. Data at state level for number and types of rural production units and land tenure.

Anguiano, José; Caracterización Ambiental del Área productora de Aguacate de Michoacán; 1st Avocado Congress; Uruapan, Michoacán; 15-20 Oct. 2001

Masera, Omar et al (GIRA); Dinámica y uso de los recursos forestales de la Región Purépecha; 1998

Bocco, Gerardo and Manuel Mendoza; "Evaluación de los cambios de la cobertura vegetal y uso del suelo en Michoacán (1975 - 1995). Lineamientos para la ordenación ecológica de su territorio", Proyecto No. 96 06 042 Programa SIMORELOS – CONACYT Informe Técnico; Departamento de Ecología de los Recursos Naturales, Instituto de Ecología, UNAM Campus Morelia, Morelia, Michoacán, Febrero de 1999

Bocco, Gerardo, Manuel Mendoza and Omar R. Masera; La Dinámica Del Cambio Del Uso Del Suelo En Michoacán. Una Propuesta Metodológica Para El Estudio De Los Procesos De Deforestación; Instituto de Ecología, UNAM (Campus Morelia). Morelia, Mich.

Coria, M and Martínez, A. 1996; Cuantificación de las plantaciones aguacateras del estado de Michoacán. Memoria del IV Simposio la Investigación y el desarrollo tecnológico en Michoacán. Morelia del 9-11 de diciembre de 1996.

ANNEX I. CALAKMUL MUNICIPALITY: RESULTS FROM LUCS MODEL

YEAR	POPULATION		LAND USE (HA)								TOTAL	STANDING BIOMASS		CUMULATIVE Carbon EMMITED (TON)
	Inhabi-tants	growth rate	SELVA	SAVANNA	FOREST FALLOW LAND				SECOND FOREST	SHIFTING AGR.			C stock	
					CAT 1	CAT 2	CAT 3	SUB TOTAL			(HA)	(M TON)	(M TON)	
2000	17,000	4.00%	1,261,641	15,856	7,040	7,040	7,040	21,120	11,671	8,449	**1,318,737**	147.153	73.576	
2001	17,676	3.78%	1,261,526	15,698	7092	7,045	7,040	21,177	11,600	8,736	**1,318,737**	147.137	73.568	**0.008**
2002	18,341	3.57%	1,261,346	15,541	7,221	7,092	7,050	21,363	11,521	8,966	**1,318,737**	147.115	73.558	**0.019**
2003	18,991	3.36%	1,261,069	15,386	7,379	7,185	7,088	21,652	11,441	9,189	**1,318,737**	147.085	73.543	**0.034**
2004	19,624	3.15%	1,260,705	15,233	7,550	7,312	7,159	22,021	11,361	9,417	**1,318,737**	147.048	73.524	**0.052**
2005	20,235	2.94%	1,260,269	15,081	7,732	7,463	7,262	22,457	11,280	9,650	**1,318,737**	147.005	73.503	**0.074**
2006	20,822	2.73%	1,259,781	14,931	7,920	7,629	7,391	22,940	11,199	9,886	**1,318,737**	146.958	73.479	**0.098**
2007	21,381	2.52%	1,259,254	14,782	8,112	7,807	7,541	23,460	11,118	10,123	**1,318,737**	146.907	73.454	**0.123**
2008	21,909	2.31%	1,258,707	14,635	8,306	7,992	7,705	24,003	11,036	10,356	**1,318,737**	146.855	73.428	**0.149**
2009	22,403	2.10%	1,258,147	14,489	8,500	8,182	7,881	24,563	10,955	10,583	**1,318,737**	146.802	73.401	**0.175**
2010	22,861	1.89%	1,257,589	14,345	8,690	8,373	8,064	25,127	10,874	10,802	**1,318,737**	146.749	73.375	**0.202**
2011	23,279	1.68%	1,257,045	14,202	8,874	8,562	8,250	25,686	10,794	11,010	**1,318,737**	146.698	73.349	**0.228**
2012	23,654	1.47%	1,256,523	14,060	9,051	8,748	8,437	26,236	10,714	11,204	**1,318,737**	146.649	73.324	**0.252**
2013	23,986	1.26%	1,256,031	13,920	9,219	8,927	8,622	26,768	10,634	11,384	**1,318,737**	146.602	73.301	**0.275**
2014	24,271	1.05%	1,255,576	13,782	9,375	9,099	8,803	27,277	10,555	11,547	**1,318,737**	146.559	73.280	**0.297**
2015	24,509	0.84%	1,255,169	13,644	9,518	9,260	8,978	27,756	10,477	11,691	**1,318,737**	146.520	73.260	**0.316**
2016	24,696	0.63%	1,254,812	13,508	9,647	9,410	9,144	28,201	10,399	11,817	**1,318,737**	146.486	73.243	**0.333**
2017	24,833	0.42%	1,254,511	13,374	9,761	9,548	9,300	28,609	10,322	11,921	**1,318,737**	146.457	73.228	**0.348**
2018	24,918	0.21%	1,254,272	13,241	9,859	9,670	9,444	28,973	10,246	12,005	**1,318,737**	146.433	73.217	**0.360**
2019	24,951	0.00%	1,254,102	13,109	9,939	9,777	9,574	29,290	10,170	12,066	**1,318,737**	146.416	73.208	**0.369**
2020	24,951	0.00%	1,253,990	12,978	10,002	9,868	9,691	29,561	10,095	12,113	**1,318,737**	146.403	73.202	**0.375**
2021	24,951	0.00%	1,253,922	12,849	10,054	9,943	9,791	29,788	10,021	12,157	**1,318,737**	146.395	73.197	**0.379**
2022	24,951	0.00%	1,253,895	12,721	10,097	10,005	9,877	29,979	9,947	12,195	**1,318,737**	146.390	73.195	**0.382**
2023	24,951	0.00%	1,253,902	12,594	10,134	10,057	9,949	30,140	9,874	12,227	**1,318,737**	146.387	73.194	**0.383**
2024	24,951	0.00%	1,253,938	12,469	10,165	10,100	10,010	30,275	9,801	12,254	**1,318,737**	146.388	73.194	**0.383**
2025	24,951	0.00%	1,253,997	12,344	10,192	10,137	10,061	30,390	9,729	12,277	**1,318,737**	146.390	73.195	**0.381**
2026	24,951	0.00%	1,254,077	12,221	10,214	10,168	10,103	30,485	9,657	12,297	**1,318,737**	146.394	73.197	**0.379**
2027	24,951	0.00%	1,254,171	12,100	10,233	10,194	10,140	30,567	9,586	12,313	**1,318,737**	146.399	73.200	**0.377**
2028	24,951	0.00%	1,254,283	11,979	10,248	10,216	10,170	30,634	9,514	12,327	**1,318,737**	146.406	73.203	**0.373**
2029	24,951	0.00%	1,254,404	11,860	10,262	10,234	10,196	30,692	9,443	12,338	**1,318,737**	146.414	73.207	**0.370**
2030	24,951	0.00%	1,254,534	11,742	10,273	10,250	10,217	30,740	9,373	12,348	**1,318,737**	146.422	73.211	**0.365**
DIF	**7,951**		**-7,107**	**-4,114**	**3,233**	**3,210**	**3,177**	**9,620**	**-2,298**	**3,899**	**0**	**-0.731**	**-0.365**	

ANNEX II. ASSUMPTIONS

I. Biomass

	BIOMASS (TON/HA)	CARBON (TON/HA)
SELVA (ALTA, MEDIANA and BAJA) [1]	115	57.5
GRAZED LAND (SAVANNA)	29	14.5
FALLOW LAND		
CAT 1	24.3	12.15
CAT 2	30.6	15.3
CAT 3	37.0	18.5
SHIFTING AGRICULTURE	18	9
SEC. FOREST (old acahual)	69	34.5

[1] initial; weighted average

II. Population

Initial Population	17,000 persons
Anual Population Increase rate (initial)	4%
Year Population will stabilize	20
Aver. Family size	5.19 persons

III. Fuelwood Use Parameters

Fuel wood requirement	(metric tons per person per year)
Sources of fuelwood	Forest fallow and closed forest conversion

IV. Forestry System

Hectares of managed forest harvested in a yearly basis	5,000 Ha.
Fraction of forest biomass extracted or damaged during harvest (from aging cat. 3 to cat. 2)	15%
Hectares of unmanaged forest harvested in a yearly basis	1,000 Ha.
Fraction of forest biomass extracted or damaged during harvest(from aging cat. 3 to cat. 1)	30%
Years required for forest cat. 1 to revert to forest cat. 2 biomass	20
Years required for forest cat. 2 to revert to forest cat. 3 biomass	20
Number of hectares of forest effectively protected	248,260 Ha.
Hectares of managed forest harvested in a yearly basis	5,000 Ha.

V. Agriculture System

Agriculture land biomass:	18 ton/Ha.
Shifting Agriculture Area	8,449 Ha.
Permanent Agriculture Area	0 Ha
Fallow period:	5
Productive period (constant):	2
Years required for forest fallow to revert to selva biomass	50

ANNEX II: Population in Calakmul (cont.)

II. Comunities within Mpio. Of Calakmul (with data only for 2000)

Comunidad	1980	1990	1995	2000
Agua Bendita				4
Ampliación del Aserradero				14
Araucarias				18
Arcoiris				2
Arcoiris Dos				7
Balancax				20
Benito Juarez II (Carolina)				2
Central Chiclera Altamira				2
Chamisal				4
Cinco Hermanos				2
Costa Maya				2
Deblis				1
Dos Arbolitos				2
El Campito				10
EL Cayuco				6
El Cerrito				9
El Cerro				10
El Charro				27
El Civalito				2
EL Sinai				10
El Delfin				8
El Gallinero				8
El Huiro				16
El Milagro				8
El Mirador Segundo				7
El Potrillo (chivo)				7
El Rosario				5
El Rosario				7
El Tigre				10
El Zapote				2
El Zapote				8
El Zorro				8
Farfan				5
General Diegues				9
Hermanos Silva				2
Innominado				1
Innominado				2
Innominado				2
Innominado				1
Innominado				7
Innominado				5
Innominado				3

Innominado	1
Innominado	2
Innominado	3
Innominado	4
Innominado	1
Jaguey	4
La Acacia	1
La Ceiba	9
La Ceiba	2
La Cero	2
La Doctora	2
La Envidia	1
La Esperanza	2
La Esperanza	4
La Esperanza	6
La Estrella	4
La Giralda	9
La Gloria	2
La Huasteca	2
La Libertad	8
La Llamarada	12
La Llamarada Dos	9
La Lucha	4
La Nueva Esperanza	2
La Providencia	2
La Vaca Feliz	8
La Zorra	4
Las Campanas	21
Las Delicias	103
Las Delicias II	8
Las Palmas	9
Las Palmas	19
Los Arroyo	2
Los Laureles	3
Los Manguitos	70
Los Morales	2
Rancho Aroldo	7
Rancho Cerafino	2
San Francisco	3
San Francisco	4
San Jose	1
San Jose	6
San Juan del Rio	4
San Manuel	4
San Nicolas	5
Santa Cruz	8

Santa Isabel				8
Santa Rosa				5
Sara Simon				4
Servicio Xpujil				3
Templo Naya				5
Tierra Prometida				9
Tres Hermanos				2
Tres Hermanos				7
Unidad Habitacional				77
Verde Vida				2
SUBTOTAL 2				**798**
TOTAL MPIO. CALAKMUL	**5,095**	**14,475**	**18,400**	**23,110**
TASAS DE CRECIMIENTO ANUAL	**1980-90**	11.006%	**1995-2000**	4.664%
	1990-95	4.916%	**1990-2000**	4.790%

ANNEX II: Population in Calakmul (cont.)

III. Comunidades around Mpio. of Calakmul (with data for 1995 and 2000)

Comunidad	1980	1990	1995	2000	Mpio.
Aguas Turbias	nd	nd	15	nd	?
Alianza Productora	nd	91	102	112	CANDELARIA
Altamira de Zinaparo	175	1016	1139	1156	ESCARCEGA
Arroyo de Cuba	nd	nd	128	118	CANDELARIA
Benito Juarez Garcia No 3 (Lic)	nd	177	240	280	ESCARCEGA
Bonanza	nd	17	20	4	CANDELARIA
Carlos Sansores Perez (La Paz)	nd	37	123	141	CANDELARIA
Central Chiclera Villahermosa	nd	7	12	nd	?
Chan Laguna	210	503	539	558	ESCARCEGA
Flor de Chiapas	nd	72	218	231	ESCARCEGA
Jobal,El	nd	99	100	129	ESCARCEGA
Jose Lopez PortilloNo. 1 (Lic)	nd	127	289	378	ESCARCEGA
Laguna Grande	nd	556	550	657	ESCARCEGA
Lopez Mateos (Lic Adolfo)	340	583	454	447	ESCARCEGA
Maravillas, Las	171	123	97	113	ESCARCEGA
Mirador, El	nd	nd	21	7	ESCARCEGA
Paraguas	nd	nd	26	40	CANDELARIA
Pollos, Los	nd	nd	15	8	CANDELARIA
San Dimas (Alianza II)	nd	nd	18	6	CHAMPOTON
Silencio, El	nd	nd	6	26	CANDELARIA
Silvituc	386	639	739	835	ESCARCEGA
Solidaridad	nd	nd	137	185	CANDELARIA
Tombola, La	nd	nd	25	45	CANDELARIA
Union, La (Dos Arroyos)	nd	nd	108	96	CANDELARIA
Yazuchil	nd	nd	4	nd	?
subtotal 3	**1,282**	**4,047**	**5,125**	**5,572**	

TASA SDE CRECIMIENTO ANUAL	**1980-90**	12.182%	**1995-2000**	1.687%
	1990-95	4.836%	**1990-2000**	3.249%

	1980	1990	1995	2000
TOTAL MPIO. CALAKMUL and COMMUNITIES AROUND	**6,377**	**18,522**	**23,525**	**28,682**

TASAS DE CRECIMIENTO ANUAL	**1980-90**	11.252%	**1995-2000**	4.044%
	1990-95	4.898%	**1990-2000**	4.470%

ANNEX III: Population in Calakmul

I. Communities within Mpio. of Calakmul (with datoa for 1995 and 2000)

Comunidad	1980	1990	1995	2000
11 de Mayo	nd	80	253	292
16 de Septiembre (L. Alvarado)	57	125	71	75
20 de Noviembre	211	343	318	343
A. Obregón (Zoh Laguna)	791	1098	985	1026
Aguas Amargas(San Isidro)	nd	48	68	69
Alacranes, Los	77	156	158	143
Amapola, La	nd	nd	24	19
Angeles, Los	nd	311	390	439
Arroyo Negro	44	131	182	251
Becan	nd	100	164	205
Bel Ha	nd	71	95	94
Bella Union de Veracruz (Los Chinos)	nd	68	72	77
Bleisilo	nd	124	98	130
Cana Brava	nd	81	102	152
Carlos A Madrazo	22	26	36	42
Carmen II	nd	229	290	336
Centauro del Norte	nd	56	179	254
Cerro de las Flores	nd	nd	74	94
Chichonal	nd	56	79	63
Concepción	65	180	189	203
Constitución (Km 70)	500	726	898	1057
Cristobal Colón	111	278	337	379
Dos Lagunas	nd	nd	176	221
Dos Lagunas	nd	174	228	243
Dos Naciones	nd	106	190	195
E Eugenio Casteliot I	35	44	66	64
E Eugenio Casteliot II (El Carrizal)	nd	120	210	187
Emiliano Zapata	158	64	40	112
Felipe Angeles	nd	220	192	239
Felipe Angeles II	nd	51	63	101
Guadalupe, La	nd	217	298	311
Guillermo Prieto	nd	102	94	166
Gustavo Diaz Ordaz	259	362	435	431
Heriberto Jara	nd	131	195	249
Hermenegildo Galeana	nd	137	98	123
Innominado	nd	nd	8	2
Jose Morelos Y P (Civalito)	102	162	253	325
Josefa O de Dominguez (Icaiche)	nd	107	156	211

Justo Sierra Mendez	109	94	104	124
Kiche las Pailas	nd	185	284	338
Km 120 (San José)	5	75	140	168
Lazaro Cardenas II (Ojo de Agua)	nd	239	328	356
Ley de Fomento Agropecuario (La Misteriosa)	nd	78	123	215
Lucha, La	nd	180	232	250
Lucha, La	nd	28	105	124
Manantial	nd	271	319	354
Mancalona, La (Union 20 de Junio)	nd	191	270	294
Manuel Castillo Brito	226	255	380	432
Manuel Crecencio R	68	189	271	301
Narcizo Mendoza	nd	301	273	332
Niños Heroes	nd	184	209	247
Nueva Vida	nd	72	163	179
Nuevo Becal (El 19)	262	357	345	350
Nuevo Campanario	nd	189	254	268
Nuevo Conhuas	250	250	398	535
Nuevo Paraiso	9	126	115	101
Nuevo Progreso	nd	46	35	48
Nuevo San Jose	nd	22	208	245
Nuevo Veracruz	nd	97	184	193
Pablo García	166	545	611	763
Pioneros del rio Xnoha	nd	nd	234	345
Placeres	nd	17	10	5
Plan de Ayala (5 de Mayo)	nd	163	250	297
Plan de San Luis	nd	50	50	60
Porvenir, El	nd	20	32	8
Porvenir, El	nd	362	34	33
Puebla de Morelia	77	67	104	117
Refugio, El	nd	71	107	95
Ricardo Flores Magón	nd	151	175	215
Ricardo Payro Jene, Ing. (Polo Norte)	285	428	594	585
San Antonio	3	20	18	29
San Miguel	nd	82	78	105
Santa Lucia	298	240	245	241
Santo Domingo (El Sacrificio)	nd	nd	14	367
Tambores de Emiliano Zapata, Los	nd	134	159	195
Tepeyac	nd	17	12	18
Tesoro, El	nd	191	288	344
Tomas Aznar (La Moza)	151	167	176	177
Tres Reyes	nd	nd	68	6
Unidad y Trabajo	86	61	83	138

Valentín Gomez Farias	10	118	203	264
Veintidos de Abril	nd	12	40	17
Veitiuno de Mayo (Lechugal)	nd	130	163	216
Victoria, La	nd	136	120	201
Virgensita de la Candelaria, La	nd	272	325	340
Xbonil	319	443	490	618
Xpuhil	339	865	1213	2136
subtotal 1	**5,095**	**14,475**	**18,400**	**22,312**
TASAS DE CRECIMIENTO ANUAL	**1980-90**	11.006%	**1995-2000**	3.931%
	1990-95	4.916%	**1990-2000**	4.422%

ANNEX IV: Meseta Purépecha (Población en 2000)

A	B	C	D	E	F	G	H	I	J	K	L	M
Municipio	**Pob. Total**	**Pob. Econom. Activa**	**Pob. Ocupada**	**Pob. Ocupada en sector primario**	**Población Rural (%) =E/D**	**Pob. Rural Total =F*B**	**Total Hogares**	**Miembros por hogar =N/H**	**Total de vivien-das**	**Hogares que cocinan c/leña**	**Hogares cocinan c/leña (%) =K/J**	**Población Rural usa leña (%) =L/F**
Charapan	10,898	2,296	2,273	744	0.33	3,567	2,263	4.78	2,227	1,724	77.41%	100.00%
Cherán	16,243	4,533	4,475	1,392	0.31	5,053	3,265	4.92	3,112	2,025	65.07%	100.00%
Chilchota	30,711	9,604	9,551	1,965	0.21	6,318	6,420	4.75	5,826	3,176	54.51%	100.00%
Erongarícuaro	13,161	4,120	4,064	939	0.23	3,041	2,880	4.53	2,699	1,360	50.39%	100.00%
Nahuatzen	23,221	6,420	6,351	1,971	0.31	7,207	4,821	4.78	4,610	3,468	75.23%	100.00%
Nvo Parangaricutiro	15,280	5,000	4,972	1,847	0.37	5,676	3,228	4.68	3,064	900	29.37%	79.07%
Paracho	31,096	9,614	9,572	1,166	0.12	3,788	6,653	4.63	6,122	2,575	42.06%	100.00%
Pátzcuaro	77,872	25,654	25,328	3,244	0.13	9,974	16,268	4.71	15,238	3,847	25.25%	100.00%
Peribán	20,256	6,617	6,556	3,732	0.57	11,531	4,374	4.61	4,271	876	20.51%	36.03%
Quiroga	23,893	9,027	8,991	1,047	0.12	2,782	5,307	4.47	4,785	1,371	28.65%	100.00%
Reyes, Los	57,006	19,004	18,836	4,952	0.26	14,987	13,208	4.27	12,788	2,831	22.14%	84.21%
Salvador Escalante	38,331	10,496	10,381	3,496	0.34	12,909	7,585	5.03	7,122	4,025	56.52%	100.00%
Tancítaro	25,670	6,958	6,902	4,361	0.63	16,219	5,146	4.95	5,041	3,174	62.96%	99.65%
Tangancícuaro	32,821	10,062	9,955	3,604	0.36	11,882	7,907	4.09	7,694	1,658	21.55%	59.52%
Taretan	13,287	3,997	3,965	1,662	0.42	5,569	3,068	4.29	2,956	1,026	34.71%	82.80%
Tingambato	11,742	3,674	3,660	1,272	0.35	4,081	2,503	4.66	2,280	1,205	52.85%	100.00%
Tzintzuntzan	12,414	4,037	4,013	687	0.17	2,125	2,521	4.88	2,392	1,034	43.23%	100.00%
Uruapan	265,699	92,537	91,360	9,201	0.10	26,759	59,634	4.37	56,453	6,557	11.61%	100.00%
Ziracuaretiro	12,879	3,681	3,632	2,019	0.56	7,159	2,701	4.74	2,595	1,002	38.61%	69.46%
TOTAL	732,480	237,331	234,837	49,301	0.21	160,628	159,752	4.52	151,275	43,834	28.98%	100.00%

Source : INEGI : Census 2000.

ANNEX V: Forest data

MUNICIPIO	superficie total (ha)	existencias maderables por genero (m3 vta)					
		pino	oyamel	encino	otras coniferas	otras hojosas	total
CHARAPAN	23,609	689,225	2,309	340,128	0	48,583	1,080,245
CHERAN	26,569	1,567,000	77,235	738,197	0	101,190	2,483,622
CHILCHOTA	32,501	737,464	0	293,735	0	65,169	1,096,368
ERONGARICUARO	21,755	573,672	0	156,598	0	35,559	765,829
NAHUATZEN	26,447	1,275,542	24,088	580,007	0	90,203	1,969,840
NUEVO PARANGARICUTIRO	33,645	2,162,210	50,145	246,755	0	39,902	2,499,012
PARACHO	26,168	807,580	1,790	93	395,069	85,570	1,290,102
PATZCUARO	34,101	1,115,080	233,569	669,457	1,571	133,200	2,152,877
PERIBAN	33,996	1,150,175	53,440	251,116	0	115,742	1,570,473
QUIROGA	16,258	282,199	2	221,673	4	17,212	521,090
REYES, LOS	31,002	3,576,215	38,806	766,000	78	95,029	4,476,128
SALVADOR ESCALANTE	55,943	2,065,389	506,579	798,782	34,120	213,861	3,618,731
TANCITARO	72,467	2,491,297	418,400	563,559	0	200,707	3,673,963
TANGANCICUARO	38,702	649,282	14,064	316,800	46	96,657	1,076,849
TARETAN	16,420	347,731	110	224,831	0	54,116	626,788
TINGAMBATO	19,862	794,273	321	382,842	0	83,263	1,260,699
TZINTZUNTZAN	13,020	87,352	0	1,426	0	992	89,770
URUAPAN	84,597	2,237,408	89,503	1,300,630	46	238,163	3,865,750
ZIRACUARETIRO	17,634	1,249,323	0	368,123	0	67,608	1,685,054
	624,696	23,858,417	1,510,361	8,220,752	430,934	1,782,726	35,803,190
		66.64%	4.22%	22.96%	1.20%	4.98%	100.00%
							35,803,190

Fuente: Secretaría de Desarrollo Agropecuario y Forestal (SDAF), 1995, Inventario Forestal Estatal, Gobierno del Estado de Michoacán. Morelia.

MUNICIPIO	superficie con cubierta forestal por clase de bosque (Has)}						Cubierta Forestal	superficie erosionada (ha)
	clase1 (<= 50 m3/ha)	clase 2 (50 -100 m3/ha)	clase 3 (100- 200 m3/ha)	clase 4 (200 - 300 m3/ha)	clase 5 (> 300 m3/ha)	total	% DE LA SUPERFICIE DEL MUNICIPIO	
CHARAPAN	1,308	1,428	4,227	1,390	234	8,587	36.37%	7,533
CHERAN	0	1,551	8,174	3,601	630	13,956	52.53%	6,408
CHILCHOTA	3,155	7,333	3,137	0	0	13,625	41.92%	4,092
ERONGARICUARO	1,466	274	4,041	329	0	6,110	28.09%	4,342
NAHUATZEN	1,556	1,455	8,510	1,348	570	13,439	50.81%	10,860
NUEVO PARANGARICUTIRO	186	236	4,718	8,065	237	13,442	39.95%	3,944
PARACHO	1,837	3,226	3,796	2,232	0	11,091	42.38%	6,416
PATZCUARO	547	3,829	6,455	2,963	428	14,222	41.71%	8,724
PERIBAN	849	2,049	2,103	2,750	1,343	9,094	26.75%	7,640
QUIROGA	1,321	2,047	2,439	52	134	5,993	36.86%	4,232
REYES, LOS	884	1,374	10,612	2,368	4,552	19,790	63.83%	6,360
SALVADOR ESCALANTE	1,014	1,680	11,141	2,843	2,775	19,453	34.77%	10,092
TANCITARO	2,225	4,524	8,294	5,046	2,291	22,380	30.88%	14,100
TANGANCICUARO	2,488	1,413	4,320	937	27	9,185	23.73%	9,252
TARETAN	1,769	2,824	2,457	0	0	7,050	42.94%	9,208
TINGAMBATO	90	295	5,351	1,123	179	7,038	35.43%	5,748
TZINTZUNTZAN	382	982	0	0	0	1,364	10.48%	2,704
URUAPAN	9,069	15,890	12,730	1,737	424	39,850	47.11%	13,126
ZIRACUARETIRO	281	2,774	9,326	663	0	13,044	73.97%	3,228
	30,427	55,184	111,831	37,447	13,824	248,713		138,009

NOTA: definición de clase según SDAF, 1995. Es un indicador de cobertura
NOTA 2: no hay datos desagregados por género en la defición de clase
Fuente: Secretaría de Desarrollo Agropecuario y Forestal (SDAF), 1995, Inventario Forestal Estatal, Gobierno del Estado de Michoacán. Morelia.

	volumen promedio por clase (m3/ha)					existencias maderables por clase de bosque (m3 vta)					
MUNICIPIO	clase1	clase 2	clase 3	clase 4	clase 5	clase1	clase 2	clase 3	clase 4	clase 5	total
CHARAPAN	33.113	77.866	143.535	229.83	343.108	28,449	110,262	559,541	294,731	87,263	1,080,246
CHERAN	33.113	77.866	143.535	229.83	343.108	0	135,755	1,290,707	836,498	220,662	2,483,622
CHILCHOTA	27.732	74.719	147.078	239.128	388.936	70,264	572,188	453,916	0	0	1,096,368
ERONGARICUARO	27.732	74.719	147.078	239.128	388.936	42,763	26,282	613,890	82,895	0	765,830
NAHUATZEN	33.113	77.866	143.535	229.83	343.108	62,132	126,279	1,239,508	315,428	226,492	1,969,839
NVO. PARANGARICUTIRO	33.113	77.866	143.535	229.83	343.108	7,949	17,057	686,697	1,693,530	93,779	2,499,012
PARACHO	33.113	77.866	143.535	229.83	343.108	62,635	222,048	517,854	487,564	0	1,290,101
PATZCUARO	29.838	77.079	145.516	239.571	371.631	17,731	312,757	906,263	723,851	192,637	2,153,239
PERIBAN	33.113	77.866	143.535	229.83	343.108	31,379	151,866	271,917	695,002	420,310	1,570,474
QUIROGA	29.838	77.079	145.516	239.571	371.631	33,994	129,818	300,805	13,677	42,796	521,090
REYES, LOS	27.732	74.719	147.078	239.128	388.936	13,376	106,336	1,805,865	592,585	1,957,964	4,476,126
SALVADOR ESCALANTE	29.838	77.079	145.516	239.571	371.631	23,915	139,206	1,665,953	665,893	1,123,762	3,618,729
TANCITARO	33.113	77.866	143.535	229.83	343.108	62,651	372,102	1,202,190	1,264,444	772,578	3,673,965
TANGANCICUARO	27.732	74.719	147.078	239.128	388.936	81,780	118,426	613,719	251,014	11,909	1,076,848
TARETAN	33.113	77.866	143.535	229.83	343.108	55,549	237,802	333,438	0	0	626,789
TINGAMBATO	33.113	77.866	143.535	229.83	343.108	2,628	18,913	880,631	300,582	57,945	1,260,699
TZINTZUNTZAN	29.838	77.079	145.516	239.571	371.631	14,160	75,609	0	0	0	89,769
URUAPAN	33.113	77.866	143.535	229.83	343.108	302,697	1,260,410	1,764,981	389,863	147,799	3,865,750
ZIRACUARETIRO	33.113	77.866	143.535	229.83	343.108	9,874	199,155	1,328,606	147,419	0	1,685,054
						923,926	4,332,271	16,436,481	8,754,976	5,355,896	35,803,550

NOTA: el volumen promedio por clase se usó por región, por ello aparecen datos repetidos

	incremento maderable por clase de bosque (m3 vta)					
MUNICIPIO	clase1	clase 2	clase 3	clase 4	clase 5	total
CHARAPAN	125	1,696	12,229	8,521	2,055	24,626
CHERAN	0	2,093	27,324	19,734	5,083	54,234
CHILCHOTA	439	12,242	13,730	0	0	26,411
ERONGARICUARO	424	634	18,545	2,446	0	22,049
NAHUATZEN	1,918	1,076	28,843	9,364	5,105	46,306
NVO. PARANGARICUTIRO	27	572	21,991	51,654	2,910	77,154
PARACHO	414	2,668	12,452	14,220	0	29,754
PATZCUARO	174	7,019	22,193	19,455	5,855	54,696
PERIBAN	188	3,718	7,667	16,882	11,241	39,696
QUIROGA	205	2,905	7,321	307	986	11,724
REYES, LOS	355	4,304	52,656	15,085	41,957	114,357
SALVADOR ESCALANTE	666	3,302	41,957	18,242	32,493	96,660
TANCITARO	1,219	10,808	35,149	34,171	18,862	100,209
TANGANCICUARO	559	2,085	14,997	5,540	154	23,335
TARETAN	411	4,576	8,746	0	0	13,733
TINGAMBATO	45	80	18,071	6,883	688	25,767
TZINTZUNTZAN	643	2,653	0	0	0	3,296
URUAPAN	3,208	31,740	44,783	9,158	3,663	92,552
ZIRACUARETIRO	96	3,961	37,743	4,446	0	46,246
	11,116	98,132	426,397	236,108	131,052	902,805

FOREST CALCULATIONS RESULTS

existencias maderables por clase de bosque (m3 vta)					
clase1	clase 2	clase 3	clase 4	clase 5	total
923,926	4,332,271	16,436,481	8,754,976	5,355,896	35,803,550
existencias maderables por clase de bosque (m3/ha vta)					
30.36533342	78.5059256	146.976071	233.796459	387.434606	143.955282

superficie con cubierta forestal por clase de bosque (Has)}					
clase1 (<= 50 m3/ha)	clase 2 (50 -100 m3/ha)	clase 3 (100- 200 m3/ha)	clase 4 (200-300 m3/ha)	clase 5 (> 300 m3/ha)	total
30,427	55,184	111,831	37,447	13,824	248,713
WEIGHT	0.33041344	0.66958656	0.7303739	0.2696261	
	1.000		1.000		

incremento maderable por clase de bosque (m3 vta)						
	clase1	clase 2	clase 3	clase 4	clase 5	total
	11,116	98,132	426,397	236,108	131,052	902,805
Annual increase m3/ha	0.365	1.778	3.813	6.305	9.480	3.630
Weighted average	0.36533	3.140610125		7.161163231		

	Open Woodland	CF1	CF2	CF3
WOOD STOCK (M3/HA)	30.37	124.35	275.22	450.00
STANDING BIOMASS (Ton/Ha)	15.18	62.18	137.61	225.00
MATURATION (RECOVERY) TIME (YEARS)	157.55	42.06	20.10	

AREA (Ha)	30,427	167,015	50,843	428

ANNEX VI: ASSUMPTIONS

POPULATION	TOTAL	RURAL
Number of inhabitants in area of study	**732,480**	**160,628**
Initial rate of Population change (% year)	**1.7026**	
Year population will stabilize	**2026**	
Family size (persons)	**4.52**	

Land Use and Biomass	Area (Ha)	Biomass (Ton)
Total area within the Project boundaries	**602,291**	
Closed Forest (aging cat's 1-3)	**218,286**	
Cat. 1 (classes 2 & 3)	167,015	62.18
Cat. 2: (classes 4 & 5)	50,543	137.61
Cat. 3: (class 5 maximum)	428	225.00
Opened Woodland	**30,427**	15.18
Forest fallow land (aging cat's 1-3)		
Restored Forest Cat. 1	**1,034**	60
Cat. 2		120
Cat. 3		200
Agroforestry (Avocado)	**52,000**	60
Permanent agriculture	**162,535**	10
Tree Plantations (aging cat's 1-3)		
Shifting agriculture		
Degraded or grazed land	**138,009**	15

Wood Products and Fuel wood Use Parameters	
Fuel wood requirement (metric tons/person/year)	1.63
Fraction of wood available for fuel wood from:	
a) Closed Forest	0.74
b) Open Woodland	1.00

Fraction of wood for permanent uses from Closed Forest	0.0
Predominant use of wood products	Lumber
Useful life of wood products	20 years

Forest Maturation time	
Years required for Closed Forest cat.1 to revert to Closed Forest cat. 2 biomass.	24
Years required for Closed Forest cat.2 to revert to Closed Forest cat. 3 biomass	12.2
Years required for degraded land to revert to Open Woodland biomass if left alone	30
Years required for open woodland to revert to Closed Forest biomass if left alone	100
Years required for degraded land to revert to Closed Forest biomass if left alone	100
Maturation time for restored forest	80

Forestry System	
Amount of Wood that can be extracted from agro forestry land for fuel wood or other purposes (Tons/ha/year)	
Number of hectares of closed forest harvested in a yearly basis (ha/year)	15,000
Fraction of Closed forest biomass extracted or damaged during harvest	0.55
Amount of wood available for fuel wood from shifting agriculture	
Description of plantations growing (aging categories, biomass)	
Number of hectares of closed forest effectively protected (Ha)	

Agriculture System	
Ratio of productivity of agroforestry to permanent agriculture (Number of persons sustained by one hectare of each type):	
Permanent agriculture (persons/ha)	1
Shifting agriculture (persons/ha)	
Agro forestry (persons/ha)	2
Change in Rate of Ag Production (percentage/year)	
Initial agriculture land for export production (Hectares)	70,000
Growth rate of Agr. land for export production (percentage/year)	3.6
Fraction of food imported (%)	29
When forest is converted, what fraction is brought to:	
Agro forestry (%)	53
Permanent Agriculture (%)	47
Shifting agriculture (%)	
Number of hectares suitable for permanent agriculture (ha)	
Years required for fallow to return to cultivation	
Cultivation period of shifting agr. (before fallow) (years)	

ANNEX VII: LUCS RESULTS FOR MESETA PUREPECHA

	LAND USE (HA.)													AVERAGE	TOTAL
			CLOSED FOREST				OPEN	RESTORED FOREST						Closed Forest	CARBON
YEAR	PERM. AGRIC.	AGRO FOREST (AVOCADO)	CF1	CF2	CF3	total CF	WOOD LAND	RF1	RF2	RF3	total RF	GRAZED LAND	TOTAL AREA	BIOMASS (TON/HA)	(TON)
2000	162,535	52,000	167,015	50,843	428	218,286	30,427	1,034			1,034	138,009	603,325	80.02	12,403,326
2001	162,954	52,473	163,073	52,241	1,907	217,221	16,196	996	37	1	1,034	152,413	603,325	81.98	12,591,074
2002	164,462	54,173	159,225	52,511	2,476	214,212	13,128	959	72	3	1,034	155,282	603,325	83.54	12,692,782
2003	166,155	56,082	155,468	52,618	2,772	210,858	12,286	923	105	6	1,034	155,876	603,325	84.96	12,767,394
2004	167,852	57,996	151,799	52,684	2,984	207,467	11,378	889	135	10	1,034	156,564	603,325	86.32	12,829,775
2005	169,525	59,882	148,217	52,697	3,168	204,082	10,226	857	162	15	1,034	157,542	603,325	87.63	12,882,048
2006	171,169	61,737	144,719	52,641	3,342	200,702	8,932	825	187	22	1,034	158,717	603,325	88.91	12,926,504
2007	172,783	63,556	141,304	52,519	3,509	197,332	7,620	794	211	29	1,034	159,966	603,325	90.16	12,963,282
2008	174,363	65,339	137,970	52,334	3,672	193,976	6,392	765	232	37	1,034	161,187	603,325	91.38	12,992,736
2009	175,910	67,083	134,714	52,093	3,830	190,637	5,316	737	251	46	1,034	162,311	603,325	92.57	13,015,124
2010	177,422	68,788	131,535	51,801	3,985	187,321	4,422	709	269	56	1,034	163,304	603,325	93.73	13,030,902
2011	178,897	70,451	128,431	51,472	4,136	184,039	3,710	683	285	66	1,034	164,160	603,325	94.87	13,041,454
2012	180,334	72,071	125,400	51,111	4,284	180,795	3,159	658	299	77	1,034	164,898	603,325	95.98	13,046,244
2013	181,732	73,648	122,441	50,724	4,428	177,593	2,739	634	311	89	1,034	165,545	603,325	97.06	13,045,645
2014	183,090	75,179	119,552	50,321	4,569	174,442	2,417	610	323	101	1,034	166,129	603,325	98.12	13,041,037
2015	184,406	76,664	116,731	49,908	4,706	171,345	2,171	587	334	113	1,034	166,671	603,325	99.15	13,031,839
2016	185,681	78,101	113,976	49,489	4,841	168,306	2,055	567	342	125	1,034	167,114	603,325	100.16	13,019,182
2017	186,912	79,489	111,286	49,074	4,972	165,332	2,038	545	351	138	1,034	167,486	603,325	101.14	13,002,893
2018	188,099	80,827	108,660	48,667	5,100	162,427	2,053	525	357	152	1,034	167,851	603,325	102.10	12,984,038
2019	189,241	82,116	106,096	48,269	5,225	159,590	2,077	505	364	165	1,034	168,233	603,325	103.04	12,962,764
2020	190,338	83,353	103,593	47,888	5,347	156,828	2,103	487	368	179	1,034	168,635	603,325	103.96	12,939,514
2021	191,389	84,538	101,148	47,526	5,466	154,140	2,130	468	373	193	1,034	169,060	603,325	104.85	12,913,711
2022	192,393	85,670	98,761	47,187	5,582	151,530	2,156	451	376	207	1,034	169,508	603,325	105.72	12,886,405
2023	193,351	86,750	96,431	46,870	5,696	148,997	2,182	435	378	221	1,034	169,977	603,325	106.58	12,858,524
2024	194,261	87,776	94,155	46,584	5,806	146,545	2,208	419	380	235	1,034	170,467	603,325	107.41	12,828,915
2025	195,124	88,749	91,933	46,326	5,915	144,174	2,232	403	382	249	1,034	170,978	603,325	108.22	12,798,531
2026	195,939	89,669	89,764	46,101	6,020	141,885	2,256	388	382	264	1,034	171,508	603,325	109.01	12,767,600
2027	196,378	90,164	87,645	46,512	6,124	140,281	2,363	374	382	278	1,034	172,071	603,325	109.79	12,757,943
2028	196,442	90,235	85,577	47,492	6,224	139,293	2,506	360	382	292	1,034	172,781	603,325	110.55	12,766,479
2029	196,451	90,246	83,558	48,519	6,323	138,400	2,568	347	381	306	1,034	173,592	603,325	111.28	12,775,512
2030	196,452	90,247	81,586	49,525	6,419	137,530	2,591	334	379	321	1,034	174,437	603,325	112.01	12,784,841
	33,917	**38,247**	**-85,429**	**-1,318**	**5,991**	**-80,756**	**-27,836**				**0**	**36,428**	**0**		**381,515**