INTERACTIONS OF PAYMENT FOR HYDROLOGICAL SERVICES AND FOREST TRANSITIONS: A CASE STUDY OF THE RIO CUALE WATERSHED

By

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A thesis submitted to the Faculty of Graduate Studies and Research
in partial fulfillment of the requirements of the degree of

Master of Science
(Geography)

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May 2007

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To my grandfather German Petersen Biester
whose hard work and congruency
will always be an example for me to live by.

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ABSTRACT

INTERACTIONS OF PAYMENT FOR HYDROLOGICAL SERVICES AND FOREST TRANSITIONS: A CASE STUDY OF THE RIO CUALE WATERSHED

Conversion of forest cover to agricultural fields is currently considered the main cause of deforestation in the tropics. Despite the trends of tropical deforestation, certain areas are now presenting a turnaround in forest cover. This process of forest recovery has been called forest transition, and is based on the re-growth of trees in abandoned agricultural fields. The objective of this research is to analyze the changes in the landscape of the Rio Cuale watershed, an area where a compensatory mechanism called 'Payment for Ecosystem Services' (PES) was implemented in 2005 to avoid future forest loss.

In this case-study, we used satellite imagery to detect land-use changes over time at the regional level (Landsat MSS for 1979, TM for 1990 and ETM for 2002). In addition, we randomly sampled the two landholder communities and conducted a household survey to detect land use perceptions and suitability of PES.

Our results revealed, contrary to the national trends, that the watershed has been going through a forest recovery. Survey participants identified several factors of change that drove this forest recovery process, such as a decrease in land surface cropped and increase in parcels abandonment. These were caused by rural-to-urban migration, diversification of livelihood and local policies. The survey also revealed that despite the negative rates of forest loss, landholders willingly accept conservatory mechanisms that promote forest cover preservation.

Therefore, we conclude that the forest recovery trend is due to a change in economic demography in the watershed; however, this trend may be fostered by the PES program.

RESUME

Interactions entre paiements pour services hydrologiques et transitions forestières: étude de cas du bassin hydrographique du Rio Cuale, Mexique.

La conversion de forêts en terrains agricoles est actuellement considérée comme la cause principale de déforestation dans les tropiques. Malgré les tendances à la déforestation tropicale, certaines régions présentent maintenant un revirement du couvert forestier. Ce revirement de zones forestières a été appelé transition forestière et est basé sur le regain d'arbres en zones agricoles. L'objectif de cette étude est d'analyser les changements dans le paysage du bassin versant du Rio Cuale, une région où un mécanisme de compensation nommé 'paiement pour services écologiques (PSE) a été implémenté en 2005 afin d'éviter des futures pertes forestières.

Nous avons utilisé des images satellitaires afin de détecter temporellement les changements d'utilisation du territoire au niveau régional (Landsat MSS pour 1979, TM pour 1990 et ETM pour 2002). Nous avons également réalisé des entrevues avec des ménages choisis aléatoirement dans les deux communautés propriétaires terriennes afin de déterminer les perceptions relatives à l'utilisation du territoire et l'utilité des PSE.

Nos résultats ont révélés, que contrairement aux tendances nationales, ce bassin versant présente un rétablissement des forêts. Les personnes entrevues ont identifiées plusieurs facteurs qui contribuent à ce revirement forestier, tels que la réduction de la surface cultivée et une augmentation de parcelles abandonnées. Ce processus a pour origine l'exode rural, les diversifications des modes de vies et les politiques locales. Cette enquête a également démontrée que malgré les taux négatifs de perte de couvert forestier, les propriétaires terriens acceptent volontairement des mécanismes de conservation visant à promouvoir la préservation du couvert forestier.

En conclusion, le rétablissement du couvert forestier est dû à des changements économiques et démographiques dans le basin versant, cependant cette tendance peut être promue par le programme de PSE.

ACKNOWLEDGMENTS

First I would like to thank my supervisor Dr. Raja Sengupta for his support and kindness during the research process. I also want to thank Dr. Thomas Meredith for his significant feedback to the completion of this thesis.

I'm very thankful to the Consejo Nacional de Ciencia y Tecnologia (CONACyT) in Mexico, for the grant (187375) received to accomplish my Master studies, and to the Natural Science and Engineering Research Council (NSERC) for the travel expenses.

I want to thank the Comision Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO) for giving me the Landsat ETM Image 2002 of the area of interest.

I want to thank my field assistant Claudio Fabricio Llamas who taught me much in the field, I really appreciate his help and accessibility to work long days.

Within the field I would like to thank inhabitants from *ejidos* Cuale and Jorullo who happily participated in this research. Particularly I want to thank the *ejido* authorities: Norberto Perez and Salvador Arce, who accepted us in their meetings and who offered help in every moment. Secondly I want to thank Jose Castellon and his family, Cristo and Dona Carmen, Nacho and Don Lupe, and Eriberto and his family for their hospitality. Each of them enriched my field experience.

Moreover, I want to thank all those who helped in collecting information about the Rio Cuale watershed, such as Agustin del Castillo, Ing. Toribio Quintero, Biologa Karla and Sergio Graf, who largely contributed with his feedback to this document.

Especially I want to thank my father Alfredo Bauche for his constant support in every decision I have taken in my life, always showing genuine interest in my projects. I also want to thank my mother Maria Antonia Petersen, for her constant love and understanding.

Finally, I want to thank Manfred Meiners for his important feedback to the document and the way he encourages me to look forward.

Thanks!!

INTERACTIONS OF PAYMENT FOR HYDROLOGICAL SERVICES AND FOREST TRANSITIONS: A CASE STUDY OF THE RIO CUALE WATERSHED

CHAPTER I. INTRODUCTION

Land use change practices, mainly agriculture and cattle grazing, have led to extensive alterations in ecosystems and the services they provide (Foley, *et. al*., 2005). Recently, an extensive body of literature has arisen about land-use change, mainly because of growing awareness that these alterations affect the ability of ecosystems to support human needs (Vitousek, *et. al.,* 1997; Lambin *et. al.,* 2001). However, despite the worldwide trend of deforestation due to these land-use practices, certain areas present a re-growth of abandoned agricultural fields. This turnaround in forest cover is what Mather (1992) called a forest recovery or 'forest transitions'. Forest recovery took place decades ago in developed countries, and according to recent studies it might be currently happening in certain parts of the developing world (Rudel, 1998).

Identifying the causes of changes in the landscape, either conversion from forest to agriculture or vice versa, allows a better understanding of forest dynamics and its supply of ecosystem services. Recently, numerous authors have shown how multi-disciplinary local-scale studies have contributed to the identification of causes of land-use change (Geist and Lambin, 2002; Lambin, *et. al*., 2001), and have stated that a holistic understanding of this process may be obtained throughout the integration of spatio-temporal and socioeconomic data, which allows the linkage of processes at regional and local levels (Turner and Geoghegan, 2003; Rindfuss, *et. al*., 2004; Liverman, *et. al.,* 1998; Bürgi, *et. al*., 2004; Overmars and Verburg, 2005).

Regardless of its stated importance, accurate land-use change studies which describe landscape dynamics are missing in many tropical countries (Mas, *et. al.,* 2004), and studies that integrate these change dynamics with social data are also lacking. Therefore, this research investigates land-use change dynamics in the Rio Cuale watershed, an area located on the west coast of Mexico, which is currently part of a conservation-oriented program

based on providing economic compensation. These compensatory mechanisms, called 'payments for ecosystem services', have been considered an adequate initiative to release pressure from the natural resources while contributing to local development in economically depressed areas (Pagiola, *et. al.,* 2005b).

Hence, the Rio Cuale watershed represents an interesting case-study of an area that, in addition of being part of an innovative compensatory conservation program, it presents significant changes in the landscape.

1.1 Purpose of this study:

The main objective of this research is to describe the changes in the landscape of the Rio Cuale watershed over time, understanding the causes driving these changes, and the feasibility of a compensatory program to preserve the forest cover in the watershed.

More specifically, the objectives of this research are *i.* to determine the spatial and temporal variability of land use change within the watershed, *ii*. to understand why land use change may be altering in this area, and *iii*. to explore the possibility of preserving the forest cover through payments for ecosystem services. In order to do this, the present thesis addresses three key questions:

1. How did landscape change in the Rio Cuale watershed in the period 1979 - 2002?
2. What are the underlying and proximate causes that drove this change?
3. Based on the results obtained for questions 1 & 2, is payment for ecosystem services a good option to preserve forest cover in the Rio Cuale watershed?

In order to answer the research questions, this thesis is divided into six chapters. A literature review is presented at the end of this chapter, where main topics of interest relevant to this study are discussed: land-use/land-cover change, forest transitions and ecosystem services. Chapter II is dedicated to present the study site and the methodology used to answer the research questions. Results and discussions are presented in chapters III,

IV and V. Chapter III *'Population in the Rio Cuale watershed'* describes the sample characteristics, the livelihood conditions in the watershed, and the implications of neighboring the growing city of Puerto Vallarta. Chapter IV *'A changing landscape'* presents the time series analysis carefully describing the dynamics of the landscape overtime, and the land-use insights of the participants. Chapter V *'Payment for ecosystem services in the Rio Cuale watershed'* describes the experiences of the watershed communities in the compensatory program, their perceptions about it, and the likelihood of avoiding forest loss throughout the payments. Chapter VI presents a review of the findings and the conclusions of this work.

1.2 Literature review

1.2.1 Land-use / land-cover change

Humans have altered the global land surface to a great extent (Lambin, *et. al*., 2003). Among the most important alterations of the surface are changes in *land cover* and *land use*, which have significantly contributed to biodiversity loss, degradation of soils, impacts on water quality, alteration of ecosystems goods and services, and to local and regional climate change (Meyer and Turner, 1994; Lambin, *et. al*., 2003; Linderman, *et. al.,* 2005; Foley, *et. al*., 2005; Metzger, *et. al.*, 2006).

Land cover refers to the physical state of the land. It includes topography, soil, vegetation, water and human structures, and can be changed either through conversion (change from one class of cover to another) or modification (change of conditions within a cover class) (Meyer and Turner, 1994; Briassoulis, 2000). On the other hand, *land use* is defined as the employment of land by humans, and it involves an alteration from one type of use to another (e.g. from forest to agriculture), or the intensification of a previous use (Lambin, *et. al*., 2003). Although land-use change practices seek to satisfy immediate human needs, according to Foley *et. al.* (2005) these activities often severely degrade the environment.

Land-use change can occur as a result of biophysical and human drivers (Lambin, *et. al.*, 2003). Biophysical drivers refer to those conditions of the natural environment capable of

changing land use (e.g. hurricanes, droughts, volcanic eruptions, weather and climate variations, geomorphic processes and plant succession, between others), whereas, human drivers are those human attitudes or decisions that reflect an alteration on the ecosystems. According to Lambin *et. al.* (2003) human drivers can be clustered into economic, technological, demographic, institutional, and cultural factors, which usually promote slow changes in land use; however, there are some drivers, like economic crisis or wars that trigger rapid land-use changes.

Based on their operating scale, human drivers can be divided into proximate and underlying causes of change. Geist and Lambin (2002) define 'proximate' causes of change as those human actions that directly alter the physical environment, causing a change in the use of the land. Among the proximate causes are livestock ranching, fertilizer application, wood extraction, agriculture expansion and forest burning (Geist and Lambin, 2002; Meyer and Turner, 1994). These proximate or direct causes form a tangible connection between the physical and social environments, as they represent human decision-making reflected in immediate actions that transform land use and therefore land cover (Lambin, *et. al.*, 2003). 'Underlying' causes are indirect forces that drive proximate causes of land-use and land-cover change. As stated by many authors, underlying or indirect causes refer to socio–economic, politic, or cultural variables like human population dynamics and policies (Geist and Lambin, 2002; Stephenne and Lambin, 2004). While proximate causes emerge at the local level, underlying causes initiate in the regional level, and are therefore external to individuals or communities and cannot be controlled by them (Lambin, *et. al*., 2003).

Over the past years, causes of land-use change were attributed to single factors like population growth, poverty or shifting cultivation; however, land-use change studies have moved beyond this conventional single-cause explanation, towards an understanding that land-use changes are driven by an interaction of complex forces at multiple spatial and temporal scales (Bürgi, *et. al*., 2004; Lambin, *et. al*., 2003). These causes usually rely on economic conditions mediated by institutional factors that in most cases are influenced by global dynamics (Lambin, *et. al*., 2001).

Extensive global efforts worldwide to diminish the accelerated land-use change have been implemented (Leemans and Serneels, 2004). Recent studies have proposed that due to the complex nature of land-use change dynamics, it is important to first identify where the land is changing and to what extent, before such alteration can be stopped or even reversed (Lambin, *et. al*., 2001). Local scale land-use/land-cover change projects have contributed to the understanding of different factors driving change in small areas, which has allowed researchers to make generalizations and understand the underlying forces that cause regional patterns of change, finding new opportunities to establish adequate policies on land use.

Land-use change in the neo-tropics has gained attention in the last decade due to the high rate of forest loss and its resulting global consequences. Geist and Lambin (2002 and 2004) showed that in a study based upon many local examples in Latin America, the underlying causes of tropical deforestation were economic factors, and institutional and national policies; while the most important proximate causes of change were identified as agricultural expansion, wood extraction, and extensive livestock grazing. This statement is consistent with the Millennium Ecosystem Assessment (2005) recent findings that 24% of the global ecosystems has been transformed into cultivated systems. However, estimates of change differ greatly in regions and countries.

Estimations of land-use change are not accurate for Mexico. All the same, it is widely recognized that the country is undergoing a rapid process of land-use/land-cover change (Mas, *et. al.,* 2004). Deforestation studies in the country have been carried out by different institutions using different parameters and classifications, and their imprecise results have misled researchers and policymakers' decisions concerning forest conservation (Velazquez *et. al*., 2002).

According to Bray *et. al.* (2004) the National Forestry Inventory-2000, showed that for the 1976–2000 period the annual deforestation rate for temperate forest was 0.25% and for tropical forest was 0.76%. Whereas Masera *et. al.* (1997) reported an overall annual deforestation rate of 1.29% for the mid–1980s. For the 1990s, Torres and Flores (2001) estimated a deforestation rate of 1.3%, which was considered among the highest in the world

(Burgos and Maass, 2004). Moreover, according to Torres and Flores (2001), the present forest cover in Mexico represents only half of the area covered 35 years ago.

As shown above, estimates of deforestation rates in Mexico are non consistence, ranging from 365,000 to more than 1,500,000 hectares per year which has created a lot of confusion. However, Mas, *et. al.*, (2004) in their nation wide study for the 1976-2000 period reported an annual deforestation rate of 90,000 ha for temperate forest, 265,000 ha for tropical forest and 195,000 ha for scrubland, with deforestation rates of 0.25%, 0.70% and 0.33% per year, respectively. This suggested an overall annual deforestation rate of 0.51% and 1.3% for 1976-2000 and 1993-2000 respectively, taking into account both tropical and temperate forests. Moreover, the authors showed that most of the deforested area in the country is represented in few states (Yucatan, Chiapas, Nuevo Leon and Tamaulipas). The FAO's (2006) recent study on Forest Resource Assessment also reported that for the period 1990-2005 the overall forest cover loss (including all ecosystems) in the country was 4,778,000 ha, corresponding to 318,533.3 ha per year, with an annual deforestation rate of 0.49%.

Despite the several contradictory sources of information concerning deforestation in Mexico, understanding the causes of these land-use changes at the local level has become a critical issue in attempts to avoid land degradation (Lambin, *et. al*., 2003; Foster, *et. al*., 2003); consequently, the causes of deforestation in Mexico are now becoming widely studied.

Dirzo and Garcia (1992) in their study in Los Tuxtlas, found that population density was considered as the primary driver of land-use change, due to the fact that population increase was accompanied by a corresponding increase in the number of people dedicated to activities such as timber extraction and cattle ranching, leading to an increment in land-use change in the region. However, Ochoa-Gaona and Gonzalez-Espinosa (2000) argue in their study in Chiapas, that even though land-use change causes include the need of rural communities for timber, fuel, food and other products, factors other than population density and major productive activities also had an effect on deforestation rates. They suggested that human-environment interacting variables such as water availability, land slopes and soil quality also had an important effect on land-use change. This statement is supported by the

study of Landa *et. al.* (1997) in the region La Montana, where the authors stated that the population size was not associated directly with land degradation; in contrast, issues such as levels of wealth appear to play an important role in environmental degradation.

Despite the overall trend of deforestation in tropical countries, recent studies have shown that due to diverse and very case-particular causes, small forested areas in the tropics are increasing. This process has been called 'forest transitions'.

1.2.2 Forests Transitions

According to Mather (1992) and Rudel (1998), the term 'forest transition' consists of a 'turnaround' that occurs in forest cover, when trees re-grow in a previously cleared area. Forest transition can be analyzed from two different approaches, both based upon the microeconomic indicators of the area undergoing the transition. The first explanation is based on the dynamics of the timber market, involving scarcity and supply of this product. Although this approach has been largely found in Asia, it is unlikely to be found in Latin America where forest abundance prevents the occurrence of this situation (Rudel*, et. al.*, 2005). The second explanation of forest transition is about the transformation of societies by the urbanization and industrialization processes that promote an increase in the jobs created in the cities (Rudel, 1998), as well as an increase in intensive agriculture productivity in arable and irrigable areas, leading to the abandonment of marginal non-productive lands (Klooster, 2003). According to Rudel, *et. al*., (2005), under such conditions, these remote and less productive abandoned lands will eventually present forest re-growth. This second explanation concerning the forest transition process is more likely to be happening in Latin America.

Forest transition processes occurred in temperate zone countries in the nineteenth and early twentieth centuries, where the now wealthy countries of Europe and North America experienced high rates of rural-to-urban migrations when they started to urbanize and industrialize, promoting a turnaround in their forest cover trends (Rudel, *et. al*., 2002).

According to Mather and Needle (1998), several developing countries are now presenting signs of forest recovery after many years of decreasing rates.

Recent studies have shown that tropical nations which are now undergoing urbanization and industrialization, such as Malaysia, Mexico, Brazil and the Philippines, are reporting high rural-to-urban migration trends. Therefore, researchers suggest that a tropical forest transition could occur in certain areas of the aforementioned countries (Rudel, *et. al.,* 2002). However, forest transitions in Latin America will be different to the transitions in Europe or North America, due to the fact that Latin-American landholders who migrate to the cities usually retain their farming activities and lifestyle, receiving complementary incomes from both the rural and urban livelihoods. Therefore, if a forest transition emerges in Latin America, it will be much slower that the one experienced in the developed world.

Notwithstanding the high deforestation rates in Mexico, recent studies show areas undergoing forest recovery (Bocco, 1998). These re-vegetation processes have been reported in small areas that present high migration rates in Oaxaca, Campeche and Michoacan states (Velazquez, *et. al.,* 2003; Lopez, 2006).

1.2.3 Ecosystem services

Ecosystems provide essential services and goods for society subsistence (Daily, *et. al.*, 2000). Ecosystem services are defined by Daily (1997, p.3) as "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life". More recently the Millennium Ecosystem Assessment (2005) has defined environmental services as those human benefits provided by the ecosystems.

Environmental or ecosystem goods are those products of ecosystems processes or services, such as timber, fibre, food, biomass fuel and many others, which are useful for human society; whereas ecosystem services include soil formation, pollination, seed dispersal, climate stabilization, purification of water and air, landscape beauty, and genetic resources, among others (Daily, *et. al.*, 2000; Daily, 1997; MEA, 2005). Due to the increase in human

population and its consumption capacity, the use of these ecosystem goods and services is growing fast, and as a consequence they are being severely degraded (MEA, 2005).

Ecosystem goods have historically been recognized by society as essential agents for human welfare; they do, thus, have a well established market (Daily, *et. al.,* 2000; MEA, 2005). Although the ecosystem services have been poorly understood, have not been considered in the markets, and have been given little consideration in policy making (Costanza, *et. al*., 1997; Pagiola, *et. al.,* 2005a), these services have recently been given special attention worldwide due to the fact that society is beginning to understand its direct dependence on these services for survival. Therefore, attempts are being made to preserve ecosystem services in the long-term, and they are now starting to be included in markets and policies (Echavarria, 2002).

In order to quantify and include ecosystem services in economic markets, a new wave of projects based on monetary compensation has emerged. According to Mejias and Segura (2002), the Payment for Ecosystem Services (PES) is an innovative and promising scheme that aims to create an economic mechanism where the 'beneficiaries' of certain ecosystem services pay the 'producers' of such service. Therefore, the PES has the clear objective of recognizing the efforts of landowners on landscapes from which ecosystem services are generated, which face economic loss when joining conservation schemes or performing sustainable practices (Rosa, *et. al*., 2004). These economic mechanisms are now widely recognized as appropriate initiatives to encourage and finance conservation efforts (Grieg-Gran *et. al*., 2005).

Currently, efforts have been directed to identify potential markets in four main ecosystem services: water supply, Carbon sequestration, biodiversity conservation and landscape beauty (Grieg-Gran *et. al*., 2005). The Clean Development Mechanism is a major project that aims to create carbon trading through forest-related projects. Forest landholders have demonstrated an interest in rewards from biodiversity conservation, coupled with income from an ensuing rush of ecotourists who are willing to pay for landscape beauty (Pagiola, *et. al.,* 2005a). For water preservation, the payments have been suggested as flexible compensation mechanisms in which the water users pay for the provisioning of such service.

In a watershed, these types of mechanisms involve the creation of markets between upstream landowners and downstream water users that contributes to preserving the availability and quality of the service (FAO, 2003). Particularly with water, the aim is to create local markets for this environmental good (Unisfera, 2004) due to the geographical proximity among providers and users.

Examples of PES are found globally, and although the payments have been managed differently, according to the context of each region, the central principles of the mechanisms are almost the same: downstream users pay in order to create, from conservation practices, the most attractive land-use options upstream. Therefore, the payments need to be higher than alternative land use options (i.e. cattle and agriculture) to ensure that farmers do not suffer from economic loss by opting for conservation practices, and at the same time the payments must be moderate in order to ensure the participation of the service users (Pagiola, *et. al.*, 2005b).

Many benefits result from these mechanisms. In addition to the environmental benefits, the payments represent a source of additional income to the communities that supply the service, contributing to a rise in their standard of living (Pagiola, *et. al.,* 2005). Although the payment for ecosystem services was not created as a mechanism to reduce poverty but to avoid deforestation and preserve ecosystem services, Landell-Mill and Porras (2002) stated that it can also have a positive impact in fighting poverty, if the payments are designated to the poorest communities.

Latin America has been especially receptive to the payment for ecosystem services approach (Pagiola, *et. al.,* 2005a), where countries have implemented several schemes, ranging from traditional market-based to publicly-managed mechanisms (Grieg-Gran *et. al*., 2005). Service suppliers in Latin America usually live in remote rural areas or in watershed highlands, and have low incomes due to the marginality of their land, whereas the users of the service usually live in urban centers with access to basic services and face fewer economic adversities compared to their service suppliers (Pagiola, *et. al.,* 2005b). Payments for ecosystem services concerning watershed protection have been recently implemented in

entire watersheds of many countries in Latin America, including Colombia, Ecuador, Costa Rica, Mexico, Honduras and Brazil (Unisfera, 2004).

With respect to Mexico, Burstein *et. al.* (2002a) described the vast potential of the country to offer environmental services including watershed protection, carbon sequestration, biological diversity, and landscape beauty. For that reason, many schemes have been implemented all over the country to create mechanisms that will help preserve these ecosystem services. Some of the main projects include the *Scolel Te*, a pilot project in Chiapas that aims to sequester Carbon (Rosa, *et. al.,* 2003), the *UZACHI* (Union of Zapotec-Chinantec communities) in Oaxaca, a project oriented to forest management (Burstein, *et. al.,* 2002b), the pilot PES program in the Coatepec watershed that seeks to protect the water recharge areas of the Coatepec city (Muñoz, *et. al.,* 2004), and the Zapaliname fauna area, that protects the water recharge area of Saltillo city.

Beside the projects mentioned above and many others that are still in pre-implementation stages, the Mexican Government, based on the potential of the country to generate hydrological services, implemented a nation-wide program called Payment for Hydrological Services (PHS) in 2003. The aim of the PHS program was to maintain hydrological services in certain regions of the country, by preserving forest cover in important water recharge areas. The rationale for this program was based on the fact that Mexico is considered a country with water scarcity and at the same time it has one of the highest deforestation rates in the world; therefore, as stated by Muñoz *et. al.* (2005), the program planned to interconnect forestry and water policies, in order to address both problems simultaneously. Moreover, the PHS program was created as a mechanism that could potentially alleviate poverty by reinforcing local economies in rural areas while preserving the environment (CONAFOR, 2005b).

The PHS program is based on monetary compensations to owners of forested land to maintain the hydrological services by protecting the natural cover. To achieve this, a contract is created between the landowners and the National Forestry Commission (CONAFOR), entity responsible for the operation of the program, where the former agrees to maintain forest cover and the latter agrees to pay a fixed compensation rate per hectares

during five years. The amount for this program was determined based on the average opportunity costs of land (Jaramillo, 2003; Muñoz *et. al*., 2004), and the annual amount was fixed at MXP $400 per hectare of cloud forest and MXP $300 per hectare for the rest of the forest types (CONAFOR, 2005a; Muñoz *et. al.*, 2005).

In order to enroll in the PHS program, participants and their lands were evaluated according to their eligibility. In general, the program was directed to regions located in key areas for water recharge, that had enough forested cover, and that where identified as direct suppliers of water to cities within the country. The specific qualifying requirements to participate in the PHS program were published in the Federal Official Diary (*Diario Oficial de la Federacion*) on October 3rd 2003, and are summarized as follows:

1. The area under PHS should not exceed 4,000 hectares per participant and should be at least 50 hectares. The area must have a forested cover of at least 80% of the total surface.

2. The area must be located in critical water recharge zones, or in areas undergoing scarcity and/or loss of quality of superficial water bodies.

3. The area must be linked, through water supply, to cities with more than 5,000 inhabitants. If the area is not linked to a city, then it must be within one of the 60 Priority Mountains of Mexico.

4. In cases where the beneficiaries are e*jidos* or indigenous communities, they must fulfill the organizational and legal requirements of the Mexican Agrarian Law (*Ley Agraria*) in order to participate. In addition, the decision to join the PHS program must be taken by communal agreement within the *ejido* general assembly.

5. If the beneficiaries fulfill the requirements, they must present their application within the period established.

By enrolling in the PHS program, the landowners agree to avoid changing the current land use, and are encouraged to invigilate the area under protection to avoid deleterious anthropogenic activities or natural events such as forest fires. Monitoring activities are performed by CONAFOR, who retain the authority to end the contract when agreements are not being respected by the landowners.

In the three years since the PHS started, around 480,000 ha across Mexico have been incorporated into the program (Grieg-Gran, 2006), and according to Muñoz *et. al.,* (2005), results since the year 2003 to 2005 were presented as satisfactory, showing a very low (less than 0.1%) deforestation rate in areas receiving the payments[1]. This demonstrates that mechanisms like payment for ecosystem services are feasible to implement, and under certain circumstances these types of conservation efforts prevent land-use change. However, the PHS program has not been exempt from criticism. Many authors have questioned the amount paid to the farmers, the isolation of the areas under the program, and foremost its conservation (or classic protectionism) approach. According to the CCMSS (2005) the PHS program is based on protecting the existing forest cover (paid for 'doing nothing') while eliminating the possibility of performing sustainable use of natural resources, which then forces landowners to find alternative non-forest economic activities. In addition, the PHS program has been largely criticized due to the fact that it is the State who pays for the service instead of the direct users of the water. As a result, the program has been understood as a subsidy scheme, instead of a mechanism that could encourage the formation of long-term local markets for hydrological services, i.e., a payment scheme between the real users of the water and the upstream landowners (CCMSS, 2005; Grieg-Gran *et. al.*, 2005). According to Landell-Mills and Porras (2002) those mechanisms that involve members of society usually endure longer.

As stated above, land-use change practices have largely altered ecosystems goods and services worldwide. To avoid these ecosystem alterations a new wave of projects, based on economic compensations, is arising especially in Latin America. Consequently, understanding the advantages and drawbacks of these compensatory mechanisms at the local

[1] The deforestation rate of 0.1% in those areas was caused by unintentional forest fires, not by intentional land-use change (Muñoz, *et. al*., 2005).

level has become crucial in order to avoid future forest loss. This thesis aims to describe the local experience of a rural community in Mexico, which currently presents significant changes in the landscape and recently joined a compensatory program to avoid land-use change.

CHAPTER II. METHODS

2.1. Study area: The Rio Cuale Watershed

2.1.1 The local environment

The Rio Cuale watershed is located on the West coast of Mexico in the Sierra del Cuale, a region where the mountain range *'Eje Neovolcanico Transversal'* and the *'Sierra Madre del Sur'* intersect (Quintero, 2004). According to Rzedowski (1978), the watershed is situated in a transitional biographic zone, leading to diverse environmental conditions.

The area of interest is a sub-basin of the Rio Cuale-Pitillal watershed, which belongs to the Huicila Hydrological Region (Quintero, 2004). It is comprised of a large number of intermittent and perennial rivers that are tributaries to the major river, the Rio Cuale. The Rio Cuale flows in a Southeast to Northwest direction into the Pacific Ocean, and it supplies different communities along the watershed, as well as the city of Puerto Vallarta, the closest urban center. The Rio Cuale watershed comprises 26,700 ha and presents a wide altitude range, going from the sea level up to 2,400 m.

Soils along the watershed range from eutric and distric regosols to litosols (INEGI, 1974), and climate types vary from temperate sub-humid in the highlands to semitropical sub-humid in low elevations. The annual rainfall is 1632.2 mm in the low areas, and 1447 mm in the upper parts. Rain fall is concentrated from June to October in the entire watershed (CONABIO, 2000).

Land cover varies along the area. Pine forests, pine-oak forests and cloud forests are the main vegetation types in the highlands. Continuous forest cover is present in the upper watershed, and becomes fragmented in the proximity to the villages, where a complex mosaic of forest patches, old fallows, agricultural fields and pasture lands can be found. In the middle-elevation regions, oak forest (*encineras*) is the main vegetation type, and in the lowlands the predominant vegetation is the semi-deciduous tropical forest. The lowlands present a fragmented landscape as well, with sporadic agricultural fields and fruit tree plantations, and a high presence of pasture lands.

Historically, the area has been considered ecologically important due to its high biodiversity and the presence of endemic species such as *Aechmea tuitensis* (Izquierdo and Pinero, 2000), and *Quercus cualensis,* (Gonzalez-Villareal, 2003), and endangered species such as jaguar (*Panthera onca*) and the green macaw (*Ara militaris*). Furthermore, the uninterrupted forest cover in the upper watershed has been considered an important supplier of hydrological services. For those reasons, the watershed is considered part of a Priority Terrestrial Region (*Regiones Terrestres Prioritarias*) for the National Biodiversity Commission, and also considered a Priority Mountain for the National Forestry Commission. Given the ecological importance of the region, efforts were made to create a biosphere reserve in the area, which did not succeed due to complex socio-political reasons.

2.1.2 Human settlements in the area

Three *ejidos*[2] own the land of the area of interest: *ejido* Cuale, *ejido* Jorullo and *ejido* Puerto Vallarta. The first two are typical rural *ejidos*, where traditional cropping and ranching are the main economic activities. The last one, *ejido* Puerto Vallarta, located in the coast, has been largely influenced by the growth of a tourist industry in Puerto Vallarta City, where most of the landowners have sold their parcels for urbanization. For the purpose of this study, only *ejido* Cuale and *ejido* Jorullo will be considered, due to the fact that the areas of both *ejidos* include most of the watershed area (Figure 2.1).

The rural *ejidos* in the Rio Cuale watershed are characterized by a lack of basic services and marginalized living conditions. Although most of the localities have electricity, there is a lack of running water and sewage system. Inhabitants collect water from the springs located

[2] *Ejido* is the predominant land tenure in Mexico, it consists of land given in usufruct to a group of land-less peasants as a result of the Mexican Revolution (Warman, 2001). According to Valdez *et. al.* (2006), after the revolution, the government performed a collective land reform program that resulted in the expropriation of land from large private owners and redistribution to landless peasants; however, due to the fact that it was given in usufruct, the land could not be sold, transferred or mortgaged by its concessionaires. As a consequence, the *ejido* land remained under the direct control of the government. In 1992, article 27 of the constitution concerning land tenure was modified, and it gave *ejidos* and indigenous communities the property of their lands. At present, landowners or *ejidatarios* can claim individual parcels or transfer ownership of their lands (Warman 2001).

in the highlands through a hose, and the waste is thrown into the river flow causing pollution and unhygienic living conditions. Transportation within the watershed is based on dirt roads that, during the rainy season, get damaged, leaving several localities isolated. Concerning education, there are primary schools in the most populated localities of the watershed; however, in order to attend high school, students usually migrate to Puerto Vallarta where they stay with a kin member.

2.1.2.1 Ejido Cuale

The *ejido* Cuale (from now on called Cuale), found in the upper watershed, is located in the Talpa de Allende municipality and it comprises 235 landowners or *ejidatarios*. According to the Mexican Population Council, the marginality in the municipality is considered 'medium' (CONAPO, 2006). The total area of the *ejido* is 20,200 ha, consisting mainly of well preserved temperate forest, and 10.8% of the total area is covered by corn and pasture fields (2,200 ha of estimated crop surface).

Economic activities have varied in the *ejido* over time. In the past, mining activities were the primary source of income; later, charcoal production represented a high percentage of their profits, and in the 1970s, the creation of a community-based forestry enterprise and the construction of a sawmill became their main economic activities. Despite the high diversification of activities over this time, agriculture and cattle ranching have always represented constant earnings to the *ejidatarios*. Environmental problems of the *ejido*, includes excessive acidity in the river caused by the abandonment of the mines, and the high levels of erosion due to slash and burn activities in steep areas.

2.1.2.2 Ejido Jorullo

The *ejido* Jorullo (from now on called Jorullo) is located in the municipality of Puerto Vallarta, and it is comprised of 140 *ejidatarios*. According to the National Population Council, the marginality of this municipality is 'very low' (CONAPO, 2006). It has a total area of 14,000 ha, the vast majority covered mainly with oak and tropical deciduous forest, with an estimated crop surface area covering approximately 20% (2,800 ha) of the *ejido.*

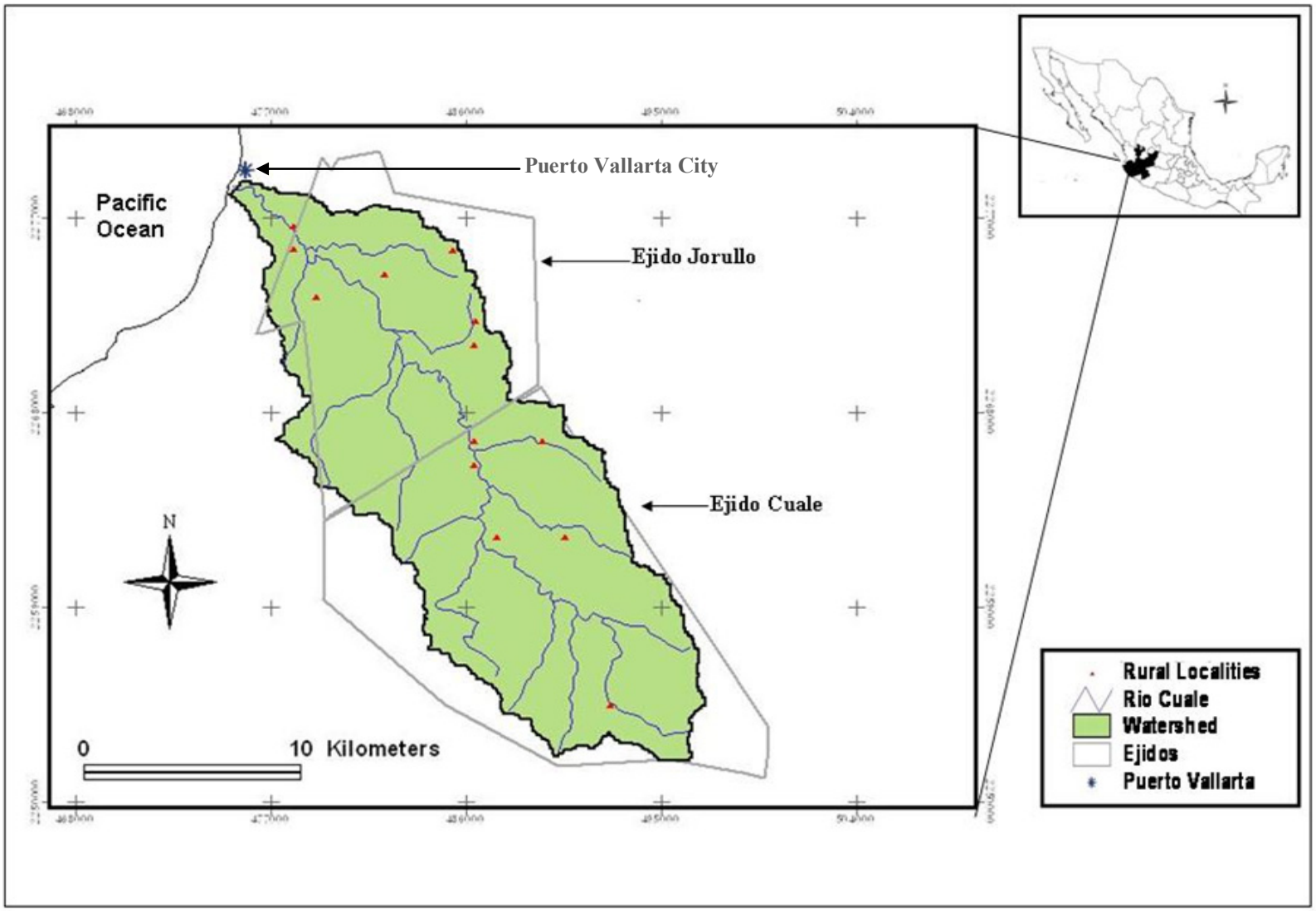

Figure 2.1 Map of the Rio Cuale watershed.

Historically, economic activities have been concentrated in pasture and corn cultivation, and livestock ranching. However, the low yields from agriculture in marginal lands, added to the little potential for timber extraction and the few job opportunities in the *ejido*, have forced its inhabitants to migrate to the urban center, where they usually perform wage labor to complement their income. Nowadays, a growing interest in ecotourism is being developed. Currently, the *ejido* faces several environmental problems such as high pollution levels in the river flow, excessive garbage on the river sides, and high levels of erosion due to slash and burn activities.

2.1.3 Historical use of natural resources in the watershed

Human settlements in the Rio Cuale watershed have been largely influenced by natural resources use. The presence of several mining and forestry companies in the region shaped the population dynamics since colonial times.

2.1.3.1 Mining

The Sierra Madre del Sur is rich in mineral soils (Gonzalez-Villarreal, 2003), which led to intensive mining activity in this area from the colonial epoch to the 19th Century. During this period, human settlements were abundant in the mountainous areas of the municipality of Talpa de Allende, where inhabitants worked mainly in the silver mines, but also in the gold, zinc and copper mines (Gonzalez-Villarreal, 2003). Mining activities during that time brought wealth to the mountainous villages. Most of the highlands inhabitants worked for the mines, and many immigrants moved to the Rio Cuale watershed localities due to availability of jobs. Such high population densities caused by the mining activities became a determining factor in the use of the local natural resources at that time. As the mining activities grew, timber supplies for the mines increased, thus temperate forests in the highlands became extremely deforested, and the high population density forced the opening of new areas for agriculture supply (Graf, 2002).

After centuries of prosperity, mineral extraction declined in the region due to two main causes: the fall in silver prices worldwide during the second decade of the 20th Century,

and instability in the country during to the Mexican Revolution. Decrease in mining activities in the mountains of the region caused migration of many families from the mountains to the coastal areas looking for jobs (Munguia, 2003). Throughout the 20th Century several mining companies arrived in the region and exploited the remaining minerals. However they never achieved the affluence of the old times. Meanwhile, inhabitants of Cuale worked in the mines intermittently, out-migrating to Puerto Vallarta when the mines shut down, and returning to the *ejido* when a new company re-opened the mines. The last mining company called Peñoles, worked in the region from 1982 to 1992 (Quintero, 2004).

2.1.3.2 Forestry

Timber extraction existed in the highlands in order to supply the intermittent mining activities; therefore it is usual to find nowadays large old areas of cleared forest in the upper watershed.

Forest extraction in the early part of the 20th Century was very destructive in the watershed. During this time, the lack of technical and scientific knowledge among the landowners about timber harvesting and the economic boom, forced the agrarian communities with forested areas to rent their lands to private owners, who started using the resources to extract cellulose in an unsustainable way (Warman, 2001). After decades of extraction by these companies, the remaining forested areas had lost most of the timber with high economic value, leaving few benefits for land-holders and creating conflicts among *ejidos* and communities (Merino, 2003). However, according to Merino (2004), by this time, despite the loss in their natural capital, the communities had reached awareness of the economic value of the forest and had achieved enough technical skills to continue sustainable forestry activities by themselves. Although Cuale had a self-consumption timber extraction permit since 1951, it was not until 1973 that the *ejido* had a commercial timber extraction permit, and only then was a communal forestry enterprise created. With the construction of a communal sawmill, profits from forestry activities became an important source of revenue for the landowners.

Meanwhile, in the lower villages of the watershed, hard wood tropical species had been heavily used for many centuries. The abundance of dye wood (brasil or palo de tinte), promoted important timber activities in the area, whereas other tropical species were used for boat and furniture construction (Munguia, 2003).

2.1.3.3 Agriculture and cattle ranching

Although mining and forestry activities have supplemented incomes over the years, inhabitants of the Rio Cuale watershed have always found stable earnings in agriculture and cattle ranching. Landowners used these activities to supply miners and foresters for centuries.

Agriculture in the area is mainly for subsistence and corn has been the principal crop in the area for years. Due to the lack of irrigation systems there is now only rain-fed agriculture in this area. Agriculture in the region is typically long-lived (fields are cultivated for many consecutive years); therefore it is considered semi-permanent rather than shifting cultivation. The sowing season is during the rainy months of June and July, and the harvest season is during December (Quintero, 2004).

Pasture, as grazing land, is a major influence in the area as well, and has lately been gaining more importance. According to Norberto Perez (personal communication), leader of Jorullo, landowners have been shifting from corn to pasture due to the little monetary requirements of pasture lands. Corn and pasture fields are located in marginal areas along the watershed due to the lack of appropriate flat areas. Therefore, yields are usually low and can only supply their immediate needs.

Extensive livestock ranching is largely performed in the watershed. This ranching system consists of using the space according to the forage availability in the different vegetation types (Graf, 2002). Based on the vegetation types, the Rio Cuale watershed presents two main ranching systems:

i. In the highlands, the cattle are left in the *agostadero* areas (pine forest) during the wet season (from June to October), whereas during the dry season they are put in the pasture lands and fed corn scraps (Quintero, 2004).

ii. In the lowlands, an important part of the forage are the pasture lands, which are mainly available during the wet season. At the beginning of the dry season cattle feed on corn scraps (Keyes and Garcia, 2001), and then left to free graze in the tropical deciduous forest, mainly in *capomeras* (*Brosimum alicastrum)* and *habilleras (Hura poliandra)* ecosystems (Graf*,* 2002*).*

During the 20th Century, agriculture and cattle ranching policies greatly impacted the watersheds' natural resources (Graf, 2002). At the national level, during the decade of 1990 the Mexican government multiplied the agricultural and cattle ranching subsidies to harmful levels in an effort to restore the agricultural production (Warman, 2001). One of the main subsidies in the region, *Procampo,* was presumed to have deleterious impacts on land use, due to the fact that it was based on cropped surface instead of cropped yield, encouraging farmers to clear new areas to increase cropped lands (Warman, 2001). After many years of ranching compensations, however, agriculture and cattle ranching subsidies are now reaching the end. Thus, farmers are finding it difficult to afford agricultural reinvestments and cope with the corn market.

2.2 Methodology

In order to accomplish the aim of the research, this study was divided into two components. The first component was a land-use change analysis to identify changes in the landscape. The second component was a survey conducted amongst the local inhabitants in order to determine their livelihood activities and perceptions about the use of their land.

2.2.1 Land-use change analysis

For the first component, concerning the spatial and temporal variability in land-use change within the watershed, we used remote sensing techniques. Remote sensing has become an efficient source of data collection that offers accurate and cost effective information to a myriad of disciplines. Due to its reliable quality and repetitive

coverage at short periods of time, remote sensing has become a good tool for monitoring changes in the landscape over time (Campbell, 1996).

For this study, Landsat imagery was used to detect changes within the watershed over a 23 year period. Due to their accessibility, the following Landsat images were used: a Multi-spectral Scanner (MSS) image from February 17th 1979, a Thematic Mapper (TM) from April 15th 1990, and an Enhanced Thematic Mapper (ETM) from the year 2002. Acquisition of these images was achieved by downloading from www.landsat.org the first two images, while the ETM 2002 image was obtained from the Mexican Biodiversity Commission (CONABIO) upon request. The images were cloud free and already geometrically corrected, identified by the Landsat Worldwide Reference System I as path 32, row 46, and by the Worldwide Reference System II as path 30, row 46.

Once the images were obtained, an unsupervised classification of each of the images was performed independently using the Software IDRISI Version 132.22 (Clark Labs). Unsupervised classification consists of discovering the spectral groups or clusters of pixels with similar reflectance characteristics within the data, having no prior knowledge regarding these groups (Guide IDRISI 1 and 2; Campbell, 1996). Each of the three images were initially classified into several clusters or spectral groups (16 clusters for 1979, 17 clusters for 1990 and 18 clusters for 2002). Subsequently, with the help of a 1996 black-and-white ortho-rectified aerial photograph (scale 1:20 000) from the National Mapping Agency and Bureau of the Census (INEGI), as well as the author's knowledge of the area, the clusters or spectral classes were grouped to create the informational classes of interest: *forest* and *non-forest*.

The class *forest* included all the forested areas, such as pine forest, pine-oak forest, tropical deciduous forest, as well as old fallows or formally abandoned fields that indicated a high degree of forest recovery. The class *non-forest* included all the anthropogenic landscape including agricultural fields, pasture lands and population centers within the *ejidos*.

Once the land-use maps were created with the informational classes of interest, an accuracy assessment of the 2002 land-use map was performed. 70 field points for the accuracy assessment were taken with a 'Magellan SportTrak Map' Global Positioning System that has 95% accuracy (less than 7 meters), during the field visit in February and March 2006. The sampling technique for the accuracy assessment was a purposive or judgmental sampling, due to the difficult topography and inaccessibility of the area. Although it was purposive, with the help of a 1:50000 topographic map, we confirmed that the sample sites adequately covered the landscape of the watershed. According to Campbell (1996), purposive samplings present disadvantages compared with other sampling methods; however the author also mentions that due to its practicality, it is a widely used technique. Thus, it is important to consider the bias of the sampling technique when presenting the accuracy assessment of this study.

Once the images were classified and the accuracy assessed, the images were vectorized in order to obtain the areas of each informational class. The areas of each land-use map were obtained independently and compared to detect changes among classes throughout the period of interest (1979 – 2002) using the software Arc View 3.3 GIS (ESRI, Inc.).

2.2.2 The survey

The second component of the study was to distinguish the perceptions among *ejidatarios* concerning changes in the local landscape, identify their livelihood options, and place the suitability of the PHS program to promote forest-cover maintenance within the context of livelihoods and perceptions. In order to identify land-use change perceptions and livelihoods, we surveyed the population by conducting a semi-structured questionnaire among the inhabitants of the two *ejidos* in the watershed.

Surveys are data-gathering techniques used to depict characteristics and perceptions of an individual or a group of people (Fink, 2006). Among the data collection tools, semi-structured questionnaires consist of a combination of multiple choice and open-ended questions (Punch, 2003). Surveys have been widely used in the social sciences due to convenience, based on low costs (in time and money), simplification of the analysis, and prevention of interviewer bias (Gillham, 2000).

The questionnaire, consisting of a mix of multiple-choice and open-ended questions (Appendix I), aimed to tackle three sets of inquiries: *i.* Demographic and socioeconomic information in each of the *ejidos*, including livelihood options, *ii.* Perceptions about land-use change in the area and its causes, and *iii.* Insights about the suitability of the PHS program to promote forest-cover preservation in the watershed.

During the months of June and July 2005, a field visit was made to the site in order to explore the possibility of performing the research within the watershed. During this time, the first step was to approach the *Comisariado Ejidal*[3] in each of the *ejidos* and ask for permission to conduct the survey among the *ejidatarios*. During this first visit, relevant information about the site was gathered that helped in the design of the survey tool.

Once permission was obtained, a list of all the *ejidatarios*, including those living outside the *ejidos*, was created. Based on this list or 'census', 42 out of 235 *ejidatarios* in Cuale and 35 out of 140 *ejidatarios* in Jorullo were randomly selected. Random sampling gave each person the same chance of being selected from a population (Fink, 2006). We surveyed only *ejidatarios*, as they are the legal owners of the land and are responsible for any change made to their portion of the land.

The questionnaire was applied by the author and a field assistant, who was previously trained, during the months of February and March 2006. After the pilot test, slight modifications were made based on responses received. The questionnaires were applied either in houses of the *ejidatarios* or in public places (plaza, convenience store, roads or fields) and usually lasted between 30 and 60 minutes. In order to record the responses, notes were carefully taken. Because of the high rates of migration, some of the interviews took place in Puerto Vallarta, where *ejidatarios* were usually harder to find.

Data gathered through the questionnaires was analyzed using SPSS Version 14.0 (SPSS, Inc.). In order to describe the *ejidatarios'* livelihood, descriptive statistics were used (means, standard deviation, ranges, and percentages), and relations among

[3] Local authority.

variables were obtained by performing differences analysis such as chi-square, t-tests analysis and correlations, in order to find differences among the two groups sampled (Fink, 2006).

In addition to the questionnaires, unstructured interviews were applied to two key informants in each *ejido*, and were conducted with the aim of obtaining information mostly about the Payment for Hydrological Services program. However, the lack of information about the program among *ejidatarios* forced us to conduct these interviews with the *comisarios* of each *ejido,* and with some other landowners recommended by the *comisario* who were sufficiently informed about the program.

CHAPTER III. POPULATION IN THE RIO CUALE WATERSHED

This chapter provides a description of the sampled population in each of the two *ejidos* surveyed, including age and gender of participants, as well as residency status within the watershed. It also describes the livelihood activities of the participants, and the variation on crop production and income between the *ejidos*.

3.1 Sample characteristics

The sample was represented mostly by men (88% and 94% for Cuale and Jorullo respectively), with an average age of 53 years (range 28 to 80 years) for respondents in Cuale, and 52 years (range 27 to 80 years) for Jorullo participants. The high number of men participating in the survey is because the majority of land rights within the area belong to them. Women who have land rights are either widows or daughters of *ejidatarios* who have died, having been recognized by the *ejido* assembly as their successors. *Ejidatarios* of first generation, those who hold agrarian titles, are now elderly (Warman, 2001); therefore, finding women with land rights is becoming more common.

Most of the participants in Cuale live within the *ejido* (95%), whereas only 5% live in Puerto Vallarta. As regards to Jorullo, 63% of the sample live within the *ejido*, 26% live in Puerto Vallarta, and 11% live partially in the *ejido* (Figure 3.1).

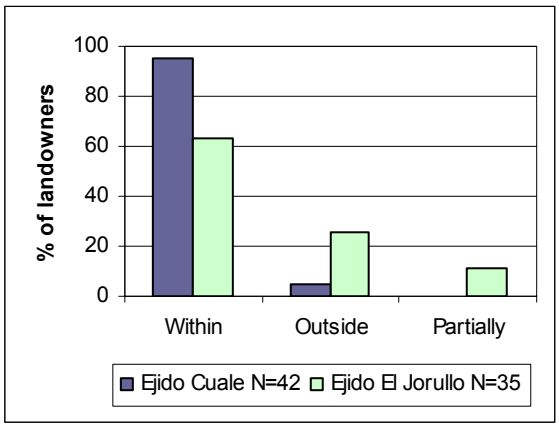

Figure 3.1 Percentage of landowners living within or outside both *ejidos*.

We found that almost half of the participants in Jorullo either have their primary residence in Puerto Vallarta or they work during the week days in the urban center returning on the weekends to their rural livelihoods. Moreover, the proximity of Jorullo to Puerto Vallarta allows some participants to commute daily to the city for work.

3.2 Livelihood in the watershed

Livelihood activities in both *ejidos* are directly related to the use of the land. Agriculture, cattle ranching, forest harvesting and charcoal production are the main economic activities in the area, which are practiced on a small scale, mainly for self-consumption. Small scale production forces participants to perform two or more of these activities simultaneously in order to complement their income.

Agricultural practices are performed by 90% of the surveyed *ejidatarios* in Cuale and by 91% of the surveyed *ejidatarios* in Jorullo. The main types of crops grown in the area are corn, pastures and to a lesser degree, a variety of fruit trees. Concerning cattle ranching, 71% and 77% of the landowners in Cuale and Jorullo respectively perform this activity. The main livestock in the area are cows, and occasionally goats and pigs. Regarding forest harvesting and charcoal production, both activities are just performed in Cuale, by 9.5% and 12% of the surveyed respondents (Figure 3.2). Forest harvesting is only performed in Cuale due to the type of ecosystem (pine forest) and because the *ejido* has a timber extraction permit as well as a communal sawmill. In addition to timber, this *ejido* also has a charcoal extraction permit; the products of both extractive activities are sold in the Puerto Vallarta market.

Respondents in Cuale have been farming on average 32 years (range: 8 - 65 years) and 35 years (range: 4 – 60 years) in Jorullo. However, according to the statements of many *ejidatarios*, rain-fed agricultural fields were already present before the decade of 1940, when both *ejidos* were formed.

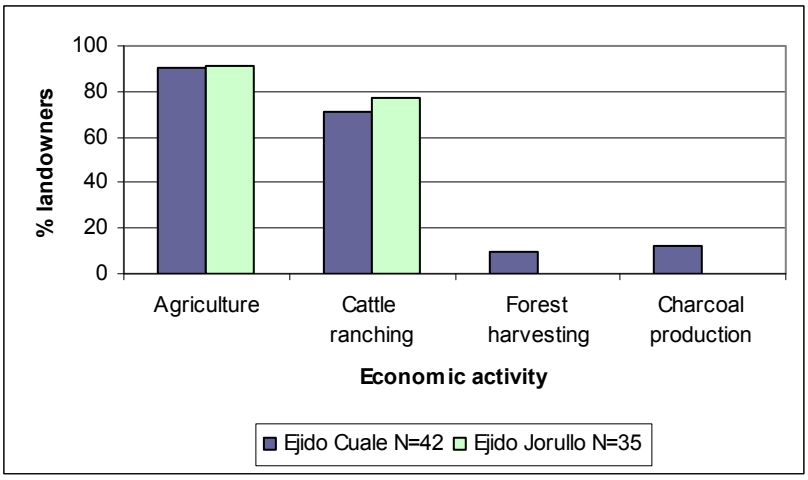

Figure 3.2 Percentage of landowners that perform different economic activities in both *ejidos*.

As previously mentioned, corn and pasture are the foremost crops in the watershed; however, its distribution varies within each *ejido*. The results showed that most of the participants in Cuale grew between 1 to 10 hectares of corn or pasture, whereas a few grew between 11 to 15 hectares, and no individuals grow more of 16 hectares of either crop. In the Jorullo, corn crops show a similar distribution than Cuale (most of the respondents grew between 1 and 10 hectares). On the contrary, pasture cultivation shows a different pattern in *ejido* Jorullo, where the majority of participants having more than 6 hectares of land in pasture, with some individuals having as much as 80 hectares of land in pasture each year (Figure 3.3 and 3.4).

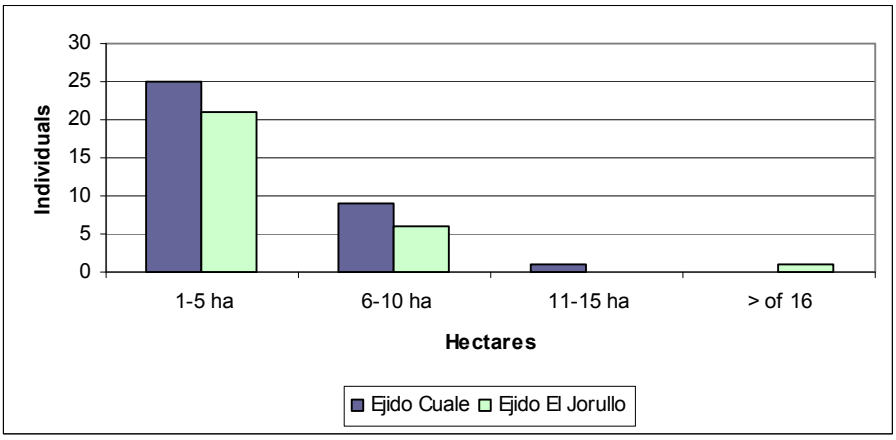

Figure 3.3 Number of landowners that grow corn in each *ejido*

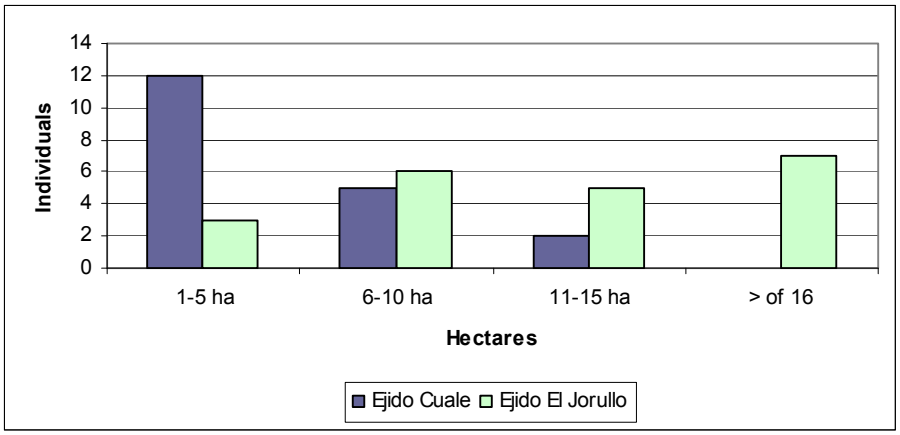

Figure 3.4 Number of landowners that grow pasture in each *ejido*

More specifically, regarding corn production, participants in Cuale grow on average 4.89 hectares of corn each year (sd=2.805; range 2 to 15 hectares), whereas in Jorullo, participants grow on average 5.09 hectares (sd=5.344; range: 1 to 30 hectares) (Figure 3.5). Although average corn production seems higher in Jorullo, no significant statistical difference (t=0.195; p=0.846) was found in the amount of corn produced by both *ejidos*.

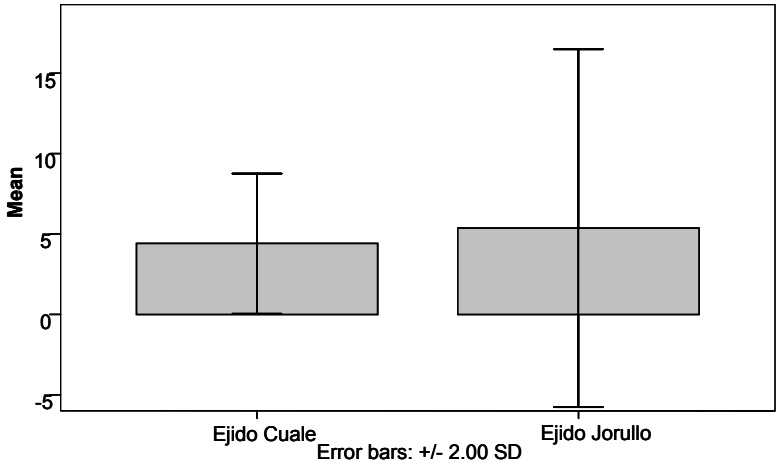

Figure 3.5 Hectares of corn produced in both *ejidos* (Cuale=4.89, Jorullo=5.09).

With regards to pasture, the average land in pasture per landowner in Cuale is 5.50 hectares each year (sd=4.173; range: 1 to 15), whereas for Jorullo the average is 17.67 hectares of pasture per farmer (sd=17.191; range: 5 to 80) (Figure 3.6). The average pasture production for both *ejidos* was statistically significant (t=3.143; p=0.005), suggesting that certainly, average pasture production in Jorullo is higher than in Cuale. Individuals with large pasture lands usually have small or no corn fields.

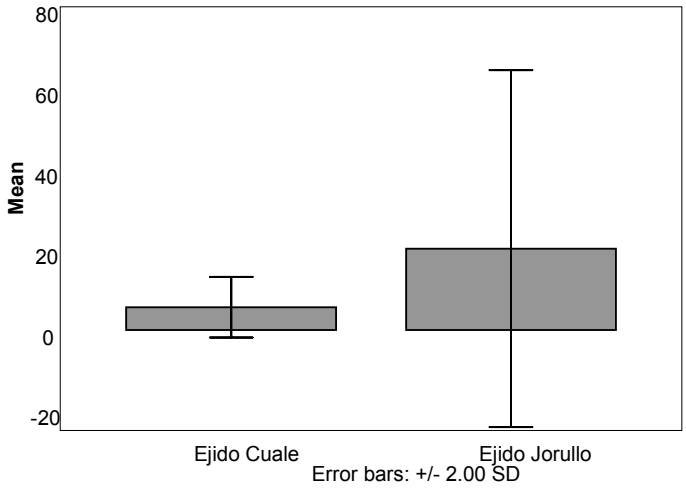

Figure 3.6 Hectares of pasture produced in both *ejidos* (Cuale=5.50. Jorullo=17.67).

The results show that corn production is performed on a small scale across the watershed, suggesting that farmers in the Rio Cuale watershed are growing corn mostly for self-consumption.

These results are similar to those found by Klooster (2002), where he mentioned that although corn production is still a strong component of rural livelihoods in Mexico, corn fields are decreasing in the Lake Patzcuaro basin. Chowdhury (2006) also found that subsistence cultivation of corn in the Maya Zone has changed to a mix of subsistence and commercial crops.

Under these conditions, pasture has become more attractive in the Rio Cuale watershed, with its cheaper production costs and high profits, and has recently become the predominant agricultural activity in the area. Pasture fields show a different pattern from one *ejido* to the other, although Cuale remains as a small scale pasture producer, some individuals of Jorullo grow pasture on a large scale and sell it as hay in Puerto Vallarta.

Farmers of both *ejidos* agreed that despite the small-scale of their agricultural activities, a majority (Cuale 95% and Jorullo 79%) produce enough to meet their family needs. Those who do not produce enough are forced to buy corn or pasture from their neighbors. In addition, a small portion of *ejidatarios* sell the surplus of their farming activities, which represents an important part of their income. According to the survey, 24% of landowners

in Cuale sell the surplus, mainly to the neighbouring localities, Puerto Vallarta and Talpa de Allende (Figure 3.7). In Jorullo, 12% of landowners sell the surplus in Puerto Vallarta and neighbouring local markets (Figure 3.8).

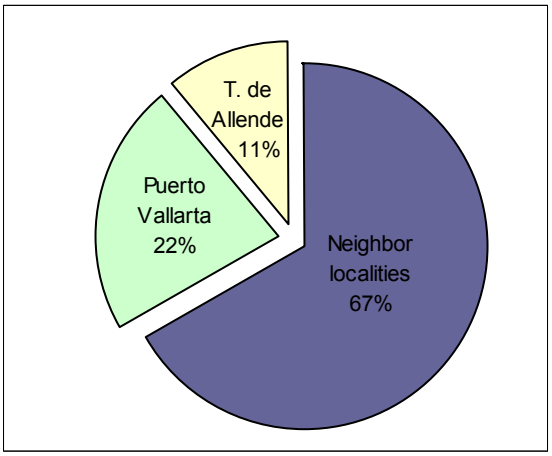

Figure 3.7 Corn and pasture markets in Cuale (N=42)

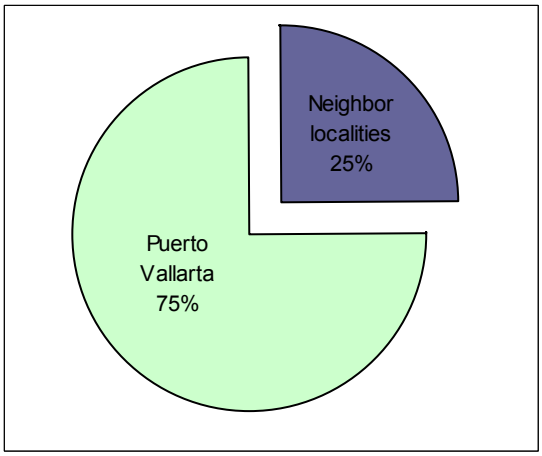

Figure 3.8 Corn and pasture markets in Jorullo (N=35)

According to Warman (2001), a rural family in Mexico consumes more than one ton of corn per year for nourishment, and around the same proportion is designated to feed the animals (pigs, chicken), therefore the total corn consumption of a rural family is approximately 2.5 Tons each year. A survey conducted in 1994 showed that 27% of the rural communities in Mexico do not reach self-consumption and buying corn is necessary to complement their consumption (Warman, 2001). However, according to our results, although agricultural activities are currently decreasing, this appears not to be the case for the two *ejidos* studied.

In addition to corn and pasture, some of the landowners also grow fruit trees. The fruit trees grown in Cuale are peach, avocado and banana. Whereas in Jorullo the main fruit trees are banana, avocado, limes, cactus, papaya, mangos and pistachio. These complementary harvests are usually for self-consumption, and in rare cases are sold to raise the farmers' income.

Cattle ranching activities have become an important economic activity in the Rio Cuale watershed, representing a high amount of the landowner's income. The main type of livestock within the watershed are cows, and occasionally goats and pigs. The average

number of cows per *ejidatario* in Cuale is 34.83 cows (sd=47.758; range: 3 to 200), while in Jorullo is 30.64 cows (sd=24.554; range: 4 to 80) (Figure 3.9), although the difference is not statistically significant (t=0.395; p=0.694). Other type of livestock such as goats and pigs is found in lower amounts in Cuale than in Jorullo.

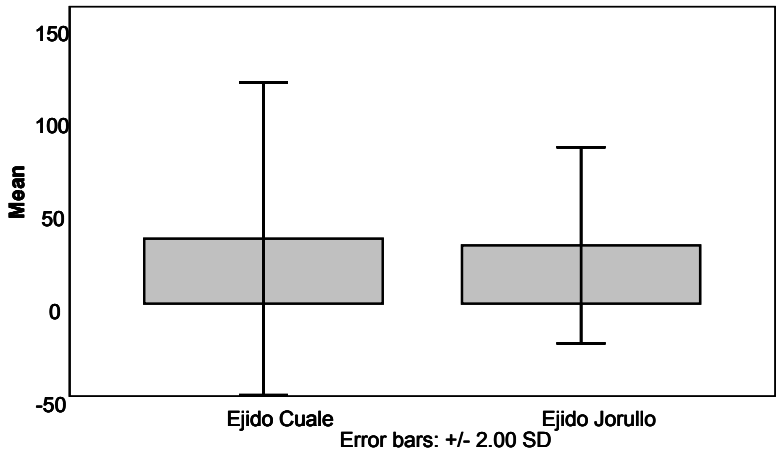

Figure 3.9 Number of cows in both *ejidos* (Cuale=34.83, Jorullo=30.64).

Survey participants revealed that the main outcomes of cattle ranching activities are bull calf and meat, which are sold in rural and urban markets. Respondent of Cuale sell their outcomes to Talpa de Allende, Puerto Vallarta or neighbouring localities (Figure 3.10); whereas Puerto Vallarta is the primary destination of cattle ranching outcomes of Jorullo (Figure 3.11).

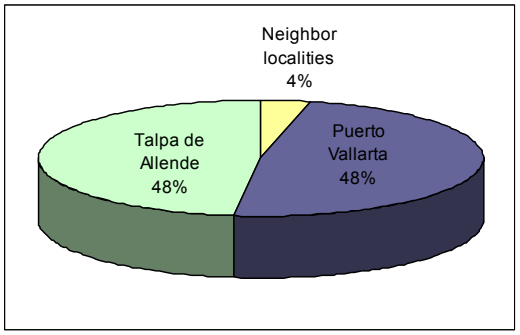

Figure 3.10 Percentage of Cuale landowners (N=42) that sell their cattle products in the different markets

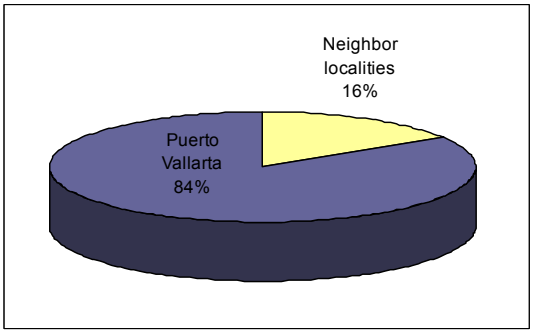

Figure 3.11 Percentage of Jorullo landowners (N=35) that sell their cattle products in different markets

Extensive cattle ranching has been highly encouraged in the region (Warman, 2001; Graf, 2002), and has become the predominant economic activity in the watershed. Cattle ranching is now considered the largest land use type in the country (Hernandez, 2001),

and it is thought to be the main driver of tropical deforestation in Mexico (Keyes and Garcia, 2001). According to Keyes and Garcia (2001), all the watersheds located in the coast of Jalisco show presence of cattle ranching activities.

Beside agriculture and cattle ranching, landowners of both *ejidos* perform diverse economic activities to complement their income, either inside or outside their *ejido*. In Cuale, 40% of the participants are engaged in an additional economic activity within the *ejido* such as owning food stores, selling guava candies, cheese or firewood, owning restaurants, taverns or billiard rooms. In some cases, a few respondents perform mechanical activities, carpentry, wage labor, or construction. During the time of the year when the sawmill is open, a large number of Cuale inhabitants are hired for timber extraction. In Jorullo, 49% of respondents perform other activities within the *ejido*, such as brick manufacturing, pasture sales, eco-tourism enterprises, craft making, dress making, cheese manufacturing, restaurant ownership, wage labor, and construction (Figure 3.12).

Due to the fact that job opportunities within the *ejidos* are limited, many landowners also perform economic activities outside the *ejido*, mainly in Puerto Vallarta. The survey showed that 17% of participants of Cuale perform some type of economic activity outside the *ejido*, which are mentioned as follows: seller of charcoal, owner of beer store, owner of food store, owner of horses for ecotourism, working in transportation, and construction (Figure 3.13). For Jorullo 43% of participants perform activities in Puerto Vallarta such as: seller of cheese, seller of firewood, seller of pasture, worker in the Municipality Government, craftsmen, owner of horses for eco-tourism, owner of restaurants and construction.

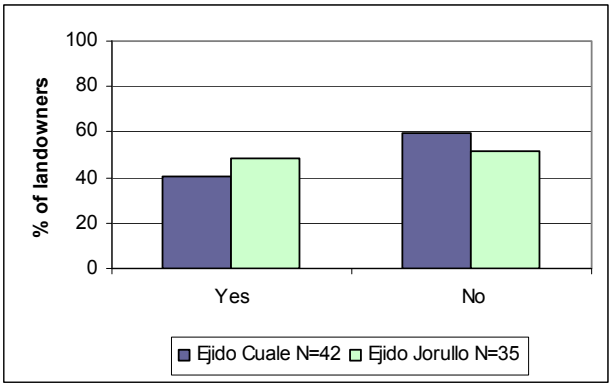

Fig 3.12 Percentage of landowners that perform additional economic activities in the *ejidos*.

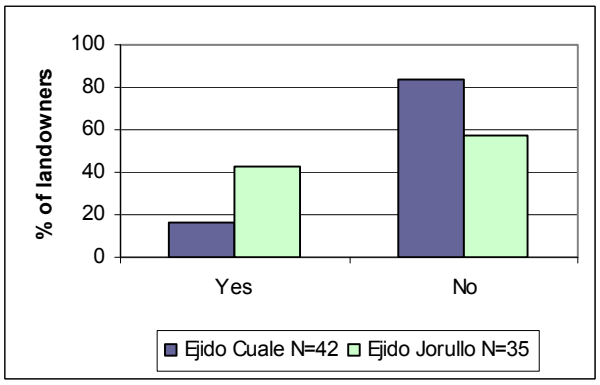

Fig 3.13 Percentage of landowners that perform additional economic activities outside the *ejidos*.

As shown in this study, livelihood diversification in the watershed is increasing. According to the respondents, livelihood in the past was based in corn production and cattle ranching, whereas nowadays off-farming activities represent a high proportion of their income.

As showed in the survey, income distribution varies between both *ejidos*. In Cuale, 43% of the respondents have a monthly income of less than MXP $1,000[4], 36% have an income between MXP $1,000 and MXP $3,000, and 21% have an income between MXP $3,000 and MXP $10,000. On the other hand, 17% of the participants in Jorullo have an income of less than MXP $1,000, 29% have an income between MXP $1,000 and MXP $3,000, 40% have an income between MXP $3,000 and MXP $10,000 and 14% have an

[4] 1 US dollar = MXP $11.28. Source: Banco de Mexico (www.banxico.org.mx, consulted in June 10th 2006).

income of more than MXP $10,000 (Figure 3.14). According to the results, participants of Jorullo have a higher income than participants of Cuale.

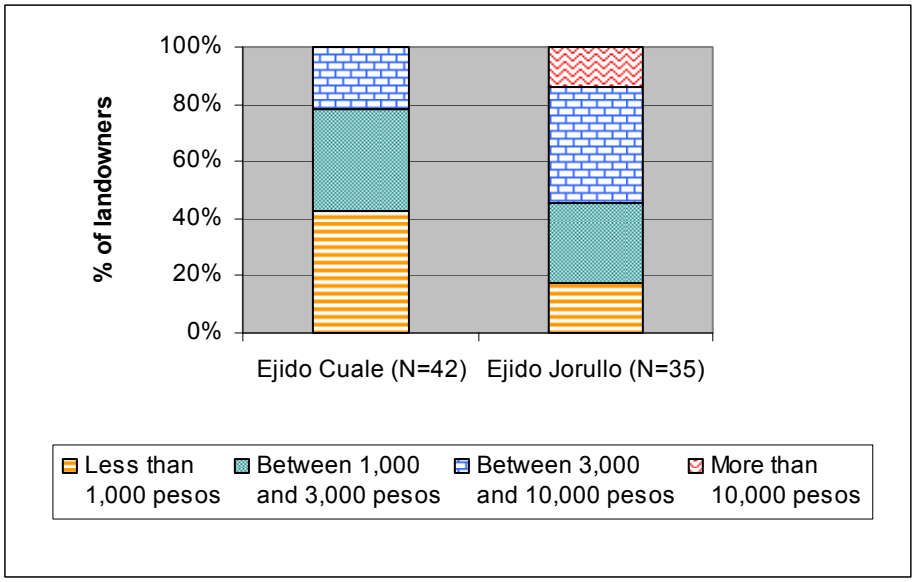

Figure 3.14 Income distribution among landowners in both *ejidos*

Cross-tabulation analysis showed no relation between having a high monthly income and performing agricultural activities (corn or pasture) in either *ejido*; whereas the number of cows possessed by a landowner was related with having high income in Cuale (x^2=45.427; p=.58), but not in Jorullo (x^2=58.144; p=.150). The analysis also showed no relationship between having a high monthly income and performing a complementary economic activity in Cuale (x^2=1.186; p=.553), whereas participants of Jorullo with higher incomes are almost always engaged in complementary economic activities within the *ejido* (x^2=10.772; p=.013). Furthermore, the analysis showed that participants who perform economic activities outside the *ejido* (mainly in Puerto Vallarta) are those with higher incomes in both cases (Cuale x^2=6.720; p=.035; Jorullo x^2=10.262; p=.016).

Consequently the results showed that owning large cropped surface of either corn or pasture does not result in a high income in either *ejido*; whereas having large numbers of cattle does, but only in Cuale, not in Jorullo. Moreover, participants in both *ejidos* with higher incomes are engage in economic activities in Puerto Vallarta. Therefore, differences in income between both *ejidos* may be explained by the proximity of Jorullo

to Puerto Vallarta, which allows its inhabitants to be engaged in economic activities tied to the urban center.

3.3 Neighbouring Puerto Vallarta

The growing tourist industry of Puerto Vallarta has positive as well as negative impacts with regard to socioeconomic activities of the neighbouring rural areas. Questions concerning perceptions of these impacts were asked during the survey. Results showed that 5% of the participants in Cuale believe the tourist industry from Puerto Vallarta has had a positive effect with respect to socioeconomic activities within the *ejido*, due to the fact that visitors buy food, fuel or request mechanical services during their stay. 95% of the landowners believe the tourism industry has no impact in the localities of the *ejido* as there are generally few people visiting the area. In fact, only 19% of the participants in this *ejido* find direct economic benefits from tourism.

In comparison, 71% of the participants in Jorullo believe the tourism industry has had a positive effect on their incomes by encouraging socioeconomic development and bringing job opportunities to the area. 9% of the participants believe tourism has a negative impact to the *ejido* due to the fact that visitors disturb the local social activities, and 20% of the respondents believe tourism has had no impact on their socioeconomic life. In this *ejido*, 40% of the participants find direct economic benefits from tourism. Participants of Jorullo agree that there is significant pressure to sell their lands to real estate dealers from Puerto Vallarta.

Cross-tabulation analysis showed that, for both *ejidos* (Cuale x^2=8.925, p=.003; Jorullo x^2=5.833, p=.016), perceptions about the impacts of tourism are related with obtaining or not obtaining economic benefits from it. Therefore, individual perceptions about the impact of tourism in the area are related to the degree with which each individual is directly benefited by this industry.

As a complementary source of income, 29% of the participants in Cuale, and 23% in Jorullo receive remittances from relatives living in Puerto Vallarta. Contrary to the rest of

the country, inhabitants of rural communities in the watershed do not migrate to the United States looking for jobs. Puerto Vallarta and its growing economy have replaced the 'American Dream' offering a myriad of job opportunities.

Remittances from the urban center have become an important component in the rural livelihoods, and according to Warman (2001), these remittances have allowed the continuity of rural livelihood and compensated for the deficit of the rain-fed agriculture in marginal lands in Mexico. This certainly seems to be the case for both the *ejidos*.

CHAPTER IV. A CHANGING LANDSCAPE

Land-use change processes are better understood when using data from both natural and social sciences, and when considering multi-scale datasets. For that reason, this chapter presents the results concerning land-use change obtained throughout two different methods:

i) a time-series analysis using remotely sensed imagery of three different dates (1979, 1990 and 2002) to detect changes at the regional level, and

ii) a survey to detect perceptions of changes in the landscape from the perspective of the individual.

The combination of disciplines and scales will provide a comprehensive description of changes in the watershed.

4.1 Time series analysis

The land-use change analysis using Landsat imagery (Multi Spectral Scanner 1979, Thematic Mapper 1990 and Enhanced Thematic Mapper 2002) revealed that the total area of forest cover within the watershed in the year 1979 was 96.7% whereas the non-forest cover was 3.3%. For the year 1990, the forest cover was 98.4% and the non-forest cover 1.6%, and for the year 2002 the forest cover represented 99.1% of the watershed and the non-forest 0.9% (Table 4.1, Figure 4.1). These results show evidence of an increase in forest cover in the Rio Cuale watershed from 1979 to 2002. The total increase of forest cover from 1979 to 1990 was 1.7% (454.57 hectares), and from 1990 to 2002 the increase in forest cover was 0.7% (185.38 hectares). The overall increase on forest cover during the 23 years period was 2.4% (639.96 hectares). The annual rate of forest recovery was 37.88 ha/year for the 1979-1990 period, and 14.26 ha/year for the 1990-2002 period.

Table 4.1 Percentage of forest and non-forest cover in the Rio Cuale watershed in 1979, 1990 and 2002.

	Percentage of land cover 1979	Percentage of land cover 1990	Percentage of land cover 2002	Percentage of change in land cover (1979-1990)
Forest	96.7	98.4	99.1	2.4
Non forest	3.3	1.6	0.9	-2.4

The accuracy assessment of the image ETM 2002 was 63%. For this study it was important to consider that between the date of the image used for the accuracy (2002) and the date when the field points were taken (2006), the landscape may have changed to some degree. However, these changes are not considered to have been significant enough to affect the overall conclusion that the forested areas increased in area over the time period analysed using Landsat imagery.

In addition to the results obtained for the entire watershed, we found that the incidence of forest recovery is present in both *ejidos*. Cuale showed a forest cover increase of 1.3% (196.62 hectares) for the period 1979–1990, and 0.9% (123.90 hectares) increase during the period 1990 to 2002, presenting an overall increase of 2.2% (320.53 hectares) during the 23 years analyzed. The annual recuperation rate during the period 1979-1990 was 16.38 ha/year, whereas for the period 1990-2002 was 9.53 ha/year.

Jorullo had a forest cover increase of 1.8% (186.38 hectares) for the period 1979-1990, and an increase of 0.6% (59.11 hectares) during 1990-2002, with an overall increase of 2.4% (245.49 hectares) for the entire period of study. Jorullo presented an annual recuperation rate of 15.53 ha/year for the period 1979-1990, and 4.54 ha/year for the period 1990-2002.

As described above, the recovery rate for forests in the watershed was higher during 1979-1990 than during 1990-2002, and Jorullo presented higher recovery rates in both periods (1979-1990 and 1990-2002) than Cuale.

Beside the rates of change along time, visual analysis allows for the detection of changes in the landscape in specific regions of the watershed. These changes were further discussed with the key informants who described the individual causes of these transformations. According to these two sources of information, we found that clearings

in the upper part of the watershed were related to the operation of the mine. These clearings persisted in the three images; however they decreased in area over time (Figure 4.2:1). Extensive forest extraction for mine supply was recognized as the primary cause of these clearings by the informants.

The presence of the mine marked another transformation in the upper watershed, such as the increase in agricultural lands in the 1990 land-use map (Figure 4.2:2). Informants stated that from 1982 to 1992 the Peñoles mining company operated in the region, and during that time employees living in the mine surroundings had crops for their subsistence, which were abandoned when the mine closed. This event explains the sudden appearance of agricultural fields in 1990, and its disappearance in 2002.

The region surrounding the Cuale locality had more forested areas in 2002 than in 1979, according to the respondents, this condition was due to a decrease in firewood and carbon extraction from the forest nearby (Figure 4.2:3). The possession of gas stoves also led to a decrease in wood use.

Further downstream in the watershed, nearby Los Lobos locality, there was an increase in agricultural fields over time (Figure 4.2:4). According to the respondents, this area has historically been considered suitable for agriculture due to its water availability and beneficial weather, and it is where most of the agricultural fields of *ejido* Cuale are located. Respondents mentioned that forest clearing for agricultural purposes is a common practice in this area, and therefore it presents a region more likely to be deforested. According to current trends, this specific area may continue to be transformed from forest to agricultural fields in the future.

Still further downstream in the watershed, west from San Juan, Cerritos and Soledad localities, there was a clear decrease in hill-side agricultural fields from 1979 to 2002 (Figure 4.2:5). The specific location of this cropping area was recognized by the respondents as a threat to the Cuale River, due to the direct drainage of agricultural chemicals. Forest recovery in this area was driven by the abandonment of the remote parcels, and in the year 2002 the only parcels remaining in agricultural use were the ones located closest to the towns.

Another area of forest cover decrease is close to Llanitos localities (Figure 4.3:6). According to the respondents, the arrival of electrical service around five years ago to this locality and its convenient proximity to the urban center, encouraged many Puerto Vallarta residents to return to their rural livelihoods, leading to an increase in surface cropped. As said by Respondent 35: "*la gente se ilusiona de regresar al rancho*" (people feel happy about moving back to their rural homes).

As we can see, pressure on the land is different along the watershed. We found that although there are areas where transformation from forest to non-forest is still predominant (Los Lobos and Llanitos areas), the majority of the watershed presents clear evidence of forest cover recovery. In the Rio Cuale watershed, the areas of deforestation are situated in accessible fields close to the localities, and the areas that show signs of forest recovery are remote and inaccessible. The aforementioned statement is concurrent with a study in the Lake Cuitzeo basin in Michoacan state, where non-irrigated agricultural lands located on steep slopes that represented low yields and hard tilling work were the ones first abandoned by farmers (Lopez*, et. al.*, 2006). Moreover, in a study in the Chiguaza region in Ecuador, forest recovery first took place in areas furthest from roads (Rudel *et. al.*, 2002).

Results from the time-series analysis suggested that, with the exception of a few areas, the Rio Cuale watershed underwent an agricultural frontier retreat from 1979 to 2002. According to Lopez *et. al.* (2006), Jalisco shows the most important relative decrease in rain-fed agriculture in Mexico. However, abandonment of agricultural fields has also been documented in other regions of the country (Klooster, 2003; Chapela, 1994; Carabias*, et. al.,* 1994). Klooster (2003) found similar results in the Lake Patzcuaro basin, in the neighboring state of Michoacan, where he discovered that a spontaneous forest regeneration took place when scrub and brush colonized abandoned agriculture fields in that area. Although Klooster (2003) mentions that the non-frontier regions in Mexico are suitable places for forest transition, Rudel (1998) states that at the national level it is unlikely we will find this trend in developing countries.

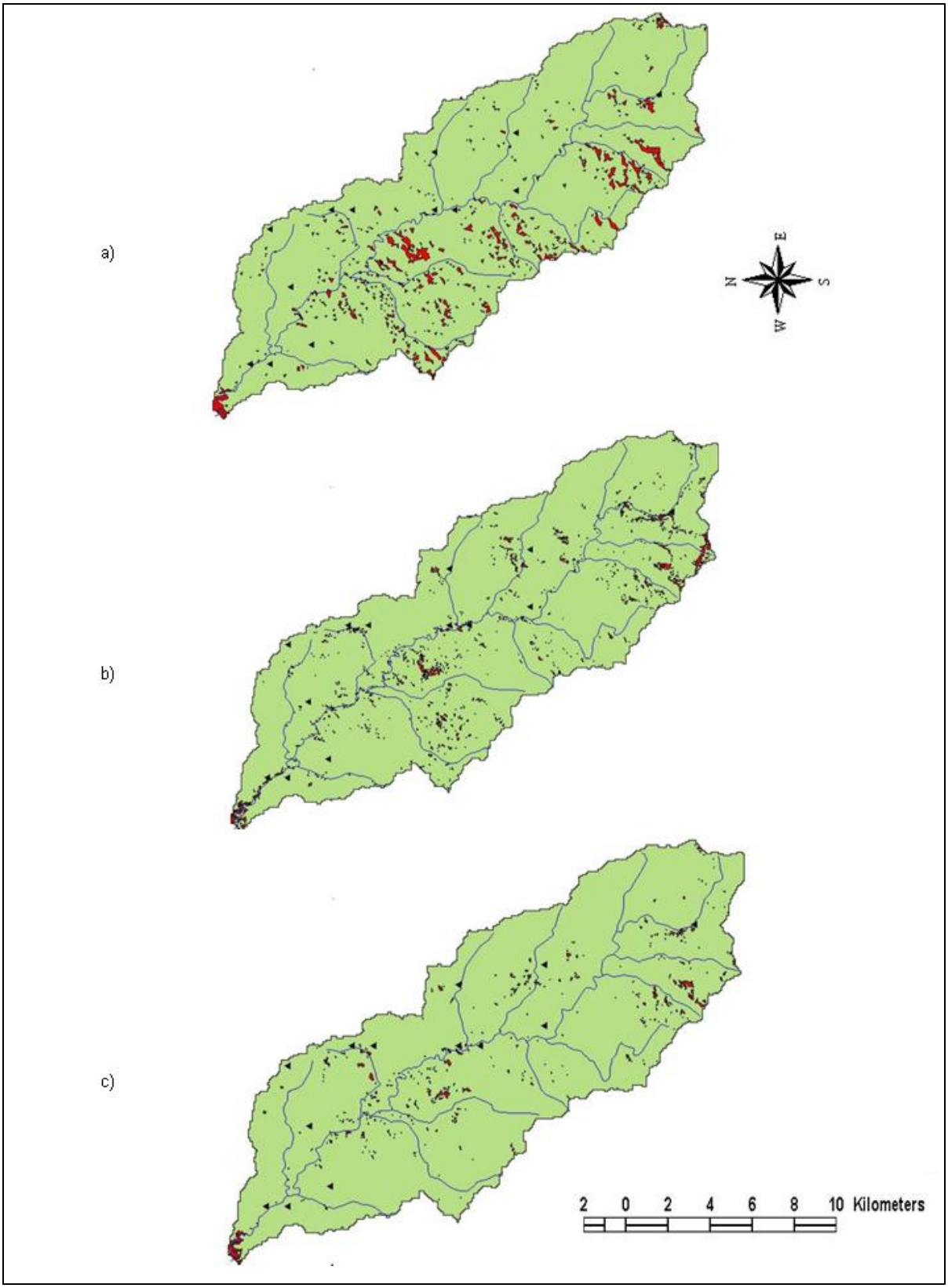

Figure 4.1 Land use maps of the Rio Cuale watershed. Forest in green, non-forest in yellow. a) 1979 b) 1990, c) 2002.

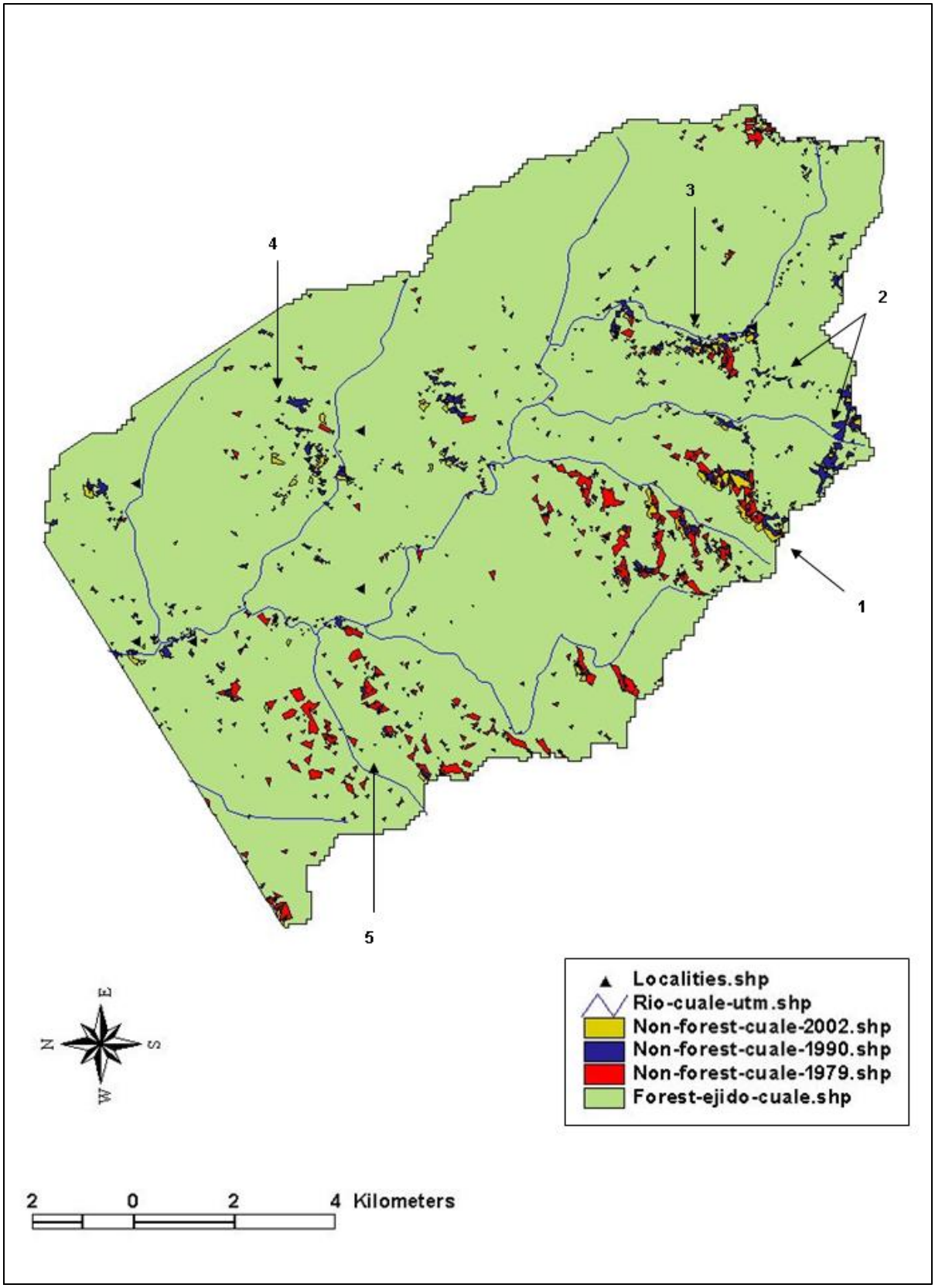

Figure 4.2 Land-use change map of *ejido* Cuale.

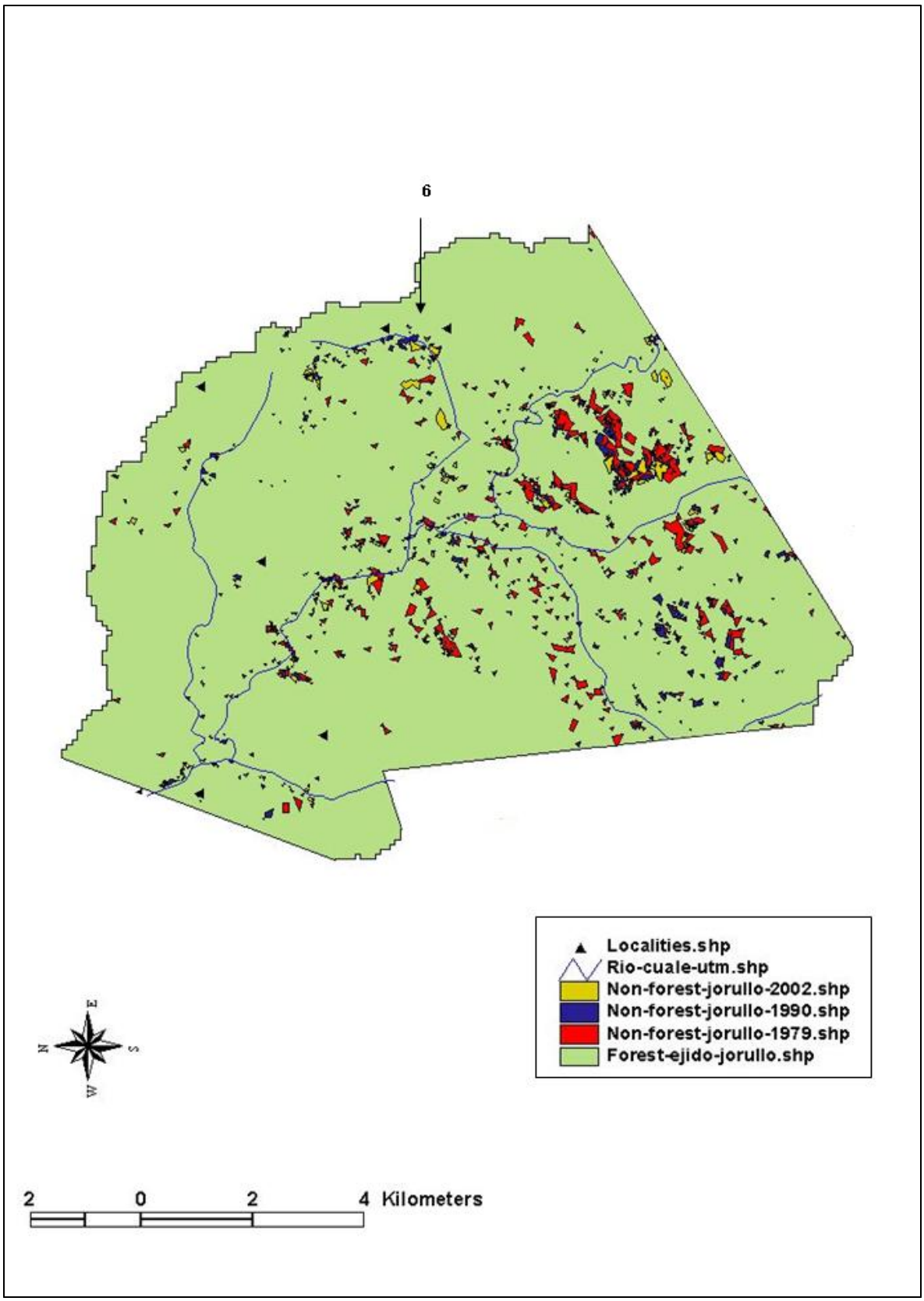

Figure 4.3 Land-use change map of *ejido* Jorullo.

4.2 Land-use insights

In addition to the information obtained from the time series analysis of Landsat imagery, throughout the survey we aimed to discover the individual perception of landscape change. In Cuale, 38% of the participants perceived that forest cover had increased in the watershed with time (1979 to 2002); whereas 33% thought the amount of forest cover had not changed in the last decade. Contrary to both perceptions, 29% believed that forest cover had decreased in the watershed since the late 70's. In Jorullo, 23% of the respondents perceived an increase in forest cover, and 34% thought that the amount of forest cover remained the same during the past 23 years. Also, 43% believe forest cover had decreased during this same period of time.

As showed above, participants had diverse and contrary perceptions concerning forest cover in the watershed. However, 71% of the participants in the upper *ejido* and 57% of the respondents in the lower *ejido* believe that forest cover had increased or remained the same for the past 23 years. According to the analysis, different perceptions on landscape change were not related to variable such as respondents' income (Cuale x^2=6.559, p=.364; Jorullo x^2=7.694, p=.565) or livelihood activities.

Key informants as well as survey participants who believe that forest cover is increasing, attribute this condition to a series of context specific conditions. They identified that the proximate drivers of forest cover increase is the decrease in agricultural activities and in cropped surface by *ejidatario*, in addition to an increase in abandoned agricultural fields that then show recovery in the form of forest fallows and secondary forest. Moreover, the survey revealed that these proximate causes of forest increase are triggered by underlying causes, such as: *a)* livelihood diversification, *b)* local policies, and *c)* rural-to-urban migration.

a) Livelihood diversification due to difficult agricultural conditions: During several decades, agriculture was the major livelihood activity in the watershed, and the farmers' single source of income. However, intensification of agriculture in specific regions, and Mexico's participation in international trade agreements, resulted in a reduction in corn prices which led to a decrease in the viability of rain-fed agriculture performed in

marginal lands (Warman, 2001). Consequently, numerous Mexican farmers decided to decrease their area under corn cultivation and abandon certain parcels (Klooster, 2002). Corn yields in the watershed are low (1.5 to 2 Ton/Ha) compared with the world average (3.6 Ton/Ha) or with the United States (7.4 Ton/Ha) (Warman, 2001); therefore, farmers now find it more profitable to buy cheap, imported corn than producing it themselves. Decrease in cropping activities also encourages an increase in livelihood diversification, due to the fact that farmers have to find a way to replace their lost agricultural income. As described in Chapter I, many landowners now have off-farm incomes from diverse economic activities, including wage labor, small businesses, and ecotourism.

Klooster (2002) reported a similar trend in the Lake Patzcuaro basin, where farmers who found it hard to cope with the corn markets, complemented their income with pottery production and other activities.

b) Local policies: around eight years ago, both *ejidos* established, through their assembly meetings, a prohibition on the clearing of forest in order to attain further parcels. These regulations stated that farmers should rely in the agricultural fields they already possessed, and that in only a very few cases the assembly was able to give permission to expand the agricultural frontier (*i.e*. when new *ejidatarios* integrate into the *ejido*). This condition promoted significantly the decrease in forest clearing in the watershed, although not all the landowners follow these regulations. According to the survey 7% of the respondents of Cuale and 9% of Jorullo are planning to expand their farm lands in the next couple of years, despite the internal non-clearing regulations. Respondents declare that their willingness to expand the agricultural frontier is due to the insufficient profits attained from the marginal lands, which are not enough to alleviate their family needs. Participants who expressed their willingness to expand their cropped areas are still few in numbers, and they all live in Los Lobos and Llanitos localities, areas within the watershed that still show a decisive rate of forest loss.

Another internal regulation that, according to the participants, has promoted forest recovery in the watershed is based on the fact that if an agricultural field is abandoned for

more than 7 years, and trees re-grow within the area, the parcel cannot be further cleared for agricultural purposes, and is left as part of the forested area.

Like the Rio Cuale watershed, common-property tenure rules were important drivers of forest recovery in the Lake Patzcuaro basin (Klooster, 2003).

c) Rural-to-urban migration: Analysis of demographic data from INEGI (2000) showed that in *ejidos* Cuale and Jorullo population has not followed a steady trend; conversely there is a clear fluctuation of people in both *ejidos* in the last decades, although during the last 15 years in Cuale and the last five years in Jorullo, there is a definite decrease in population (Figure 4.4 and 4.5). Comparing demographic information of these rural areas with the proximate urban center (Puerto Vallarta) and with the national data (Figures 4.6 and 4.7), it is evident that despite the fluctuations, during many years the watershed presented relatively stagnant population growth numbers, and currently is presenting a decrease in population.

The survey revealed several factors that have prompted rural-to-urban migration along the watershed. These factors include closure of intermittent mining activities (and hence economic opportunities), the decrease in agricultural activities, and the lack of high schools and job opportunities in the rural areas. Working in tandem, these factors encourage migration of young people to Puerto Vallarta, a city with high economic opportunities (Canales and Vargas, 2002). Migrants either return to the rural localities during the farming season to help their families with the farm, or remain in the urban center, loosing interest in their rural livelihoods. This loss of interest in farm life by the current labor force is, according to this study, contributing significantly to a decrease in cropped surface.

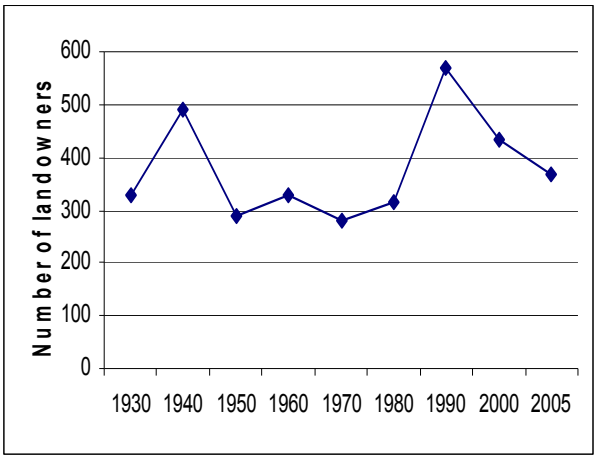

Figure 4.4 Population dynamics in *ejido* Cuale

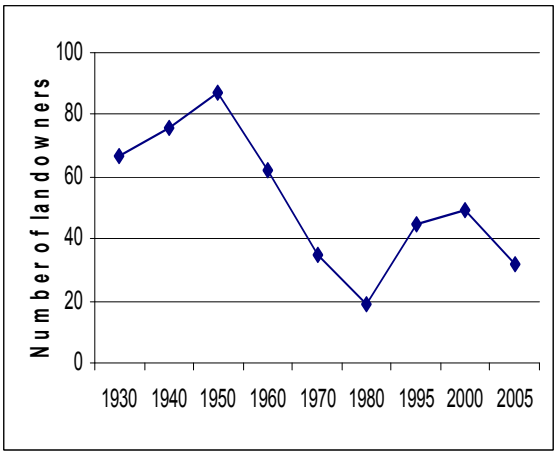

Figure 4.5 Population dynamics in *ejido* Jorullo

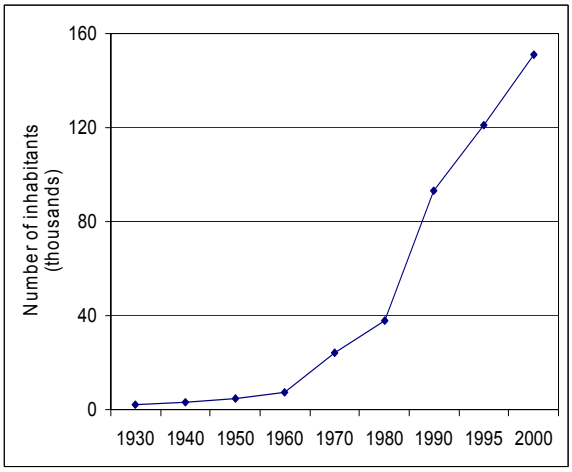

Figure 4.6 Population dynamics in Puerto Vallarta

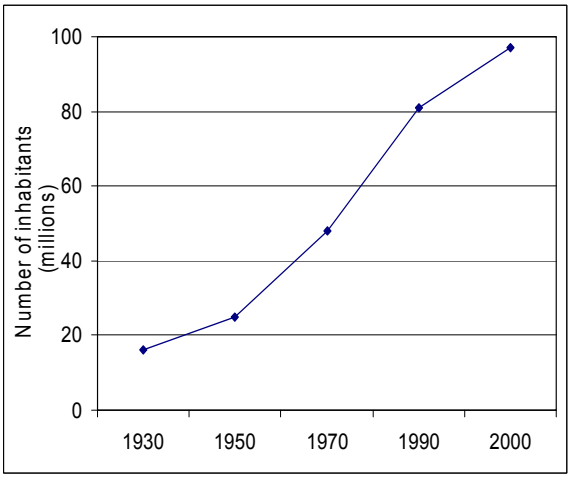

Figure 4.7 Population dynamics in Mexico

Warman (2001) identified the lack of opportunities in the rural livelihoods and the proximity to a tourist center (i.e. Cancun shows high rates of rural-to-urban migration as well) as the primary drivers of rural population expulsion in Mexico. According to the same author, migration was the most important factor in the Mexican rural demography during the 20th Century, revealing that more than half the people born in rural localities migrated to an urban center, either within the country or in the United States. However, Puerto Vallarta's fast growing economy prompts national rural-to-urban migration in the watershed, avoiding international relocation. The survey showed that only one participant in each *ejido* has kin members who migrated to the United States.

Migration is considered, in this study, as a driver of forest recovery, due to the fact that any decrease in population growth reduces human pressure on the land and, according to Rudel (1998), should promote reforestation.

CHAPTER V. PAYMENT FOR ECOSYSTEM SERVICES IN THE RIO CUALE WATERSHED

The *ejidos* within the Rio Cuale watershed were considered eligible to participate in the Payment for Hydrological Services (PHS) program due to its vast areas of well preserved forest and its role as headwaters of the water supply to Puerto Vallarta. This chapter presents an overview of the participation of the communities in the PHS program, and the perceptions of the participants about such a compensatory program, as well as their willingness to participate in conservation efforts.

5.1 Overview of the ejidos' participation in the Payment for Hydrological Services program

(i) Cuale:

In 2005, Cuale joined the PHS program. Because of the large tracts of well preserved temperate forests, according to key informants, the *ejido* decided to designate for conservation 200 hectares in the highlands of the watershed in a mountain called *Cerro Oregano,* identified by the *ejidatarios* as an important water recharge area. The area was already perceived by the *ejidatarios* as being 'strictly for conservation' due to the presence of springs that supply the communities; therefore, the area has never been cleared or cropped, and cows have never been allowed to graze within. Key informants revealed that the motivation to join the program was based on the fact that the *Cerro Oregano* was already designated for conservation, and they could not get profits from it, therefore it was evidently beneficial to receive earnings for an activity that they were already doing. As stated by Respondent #1-Cuale:

"Esta bien el programa, pero nosotros de todos modos ya cuidábamos esas áreas"
(The[PHS] program is a good idea, although we were already preserving those specific areas).

It is important to mention that Cuale has its own communal enterprise, and that *ejidatarios* are supervised by a forestry technician, who assists with the paperwork requirements, facilitated the participation of the *ejido* in the PHS program.

(ii) Jorullo:

On the contrary, key informants of Jorullo disclosed that although there has been a willingness to join the PHS program since the year 2005, they were prevented because they did not fulfill the paperwork requirements. However, they were willing to join the program in 2006, and, by the time of the interviews, they were planning to submit the necessary paper requirements. Key informants revealed that the *ejido* has enough well preserved forest cover (mainly tropical sub-deciduous), and believe the PHS program is an appropriate incentive to maintain it. Due to its hilly topography and remoteness, these well preserved areas have never been cleared and cattle have never grazed there, and *ejidatarios* are not planning to perform any farming activities in those areas in the near future. As stated by Respondent #7-Jorullo:

> *"Las [tierras] que queremos meter al programa son áreas que nunca se han tocado y que no se pensaban tocar porque están muy lejos y decidimos destinarlas para la conservación".*
>
> (The lands that we want to designate for the program are lands that have never been used and we have no plans to use them in the near future due to their remoteness; those, we decided to designate them for conservation).

As key informants mentioned, these forested areas are perceived as 'idle lands' because *ejidatarios* are not profiting from it, and they cannot sell it because it is located in the communal area of the *ejido*. Therefore, a program such as PHS appears as an attractive means to obtain income from these forested lands.

5.2 Local perceptions about a nation wide conservation program

Although Cuale joined the program in early 2005, by March 2006 not all the landowners were informed about this fact. Thus, when asked if they had heard about the PHS program that the Federal Government created in 2003, 67% of the participants of Cuale said they had and that they knew the *ejido* was participating, while 33% stated they had never heard about it (Figure 5.1). Whereas for Jorullo, results showed that although this *ejido* is not participating yet in the PHS program, 71% of respondents had heard about the PHS program while 29% had never heard about it (Figure 5.2).

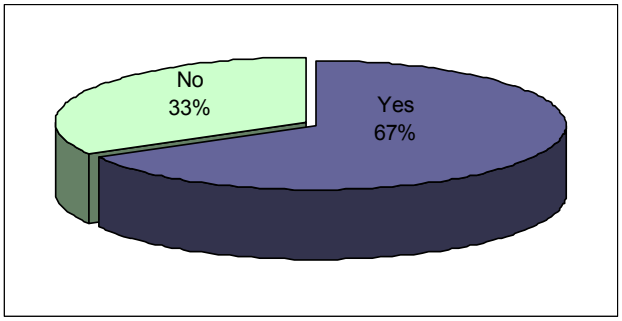

Figure 5.1 Percentage of landowners in Cuale that have heard about the PHS program created by the Federal Government.

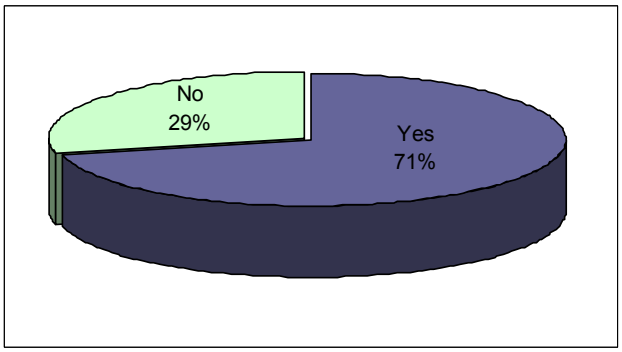

Figure 5.2 Percentage of landowners in Jorullo that have heard about the PHS program created by the Federal Government.

From those *ejidatarios* who responded that they had heard about the PHS program in both *ejidos,* the survey revealed that the respondents had learned about the program through two different sources: *i.* external promoters, such as public servants that visit the *ejido* with the aim of promoting a variety of public-programs, or *ii.* during the assembly, where all the potential projects are presented to the ejidatarios and where decisions are

made. In Cuale, 43% of the participants learned about the PHS program throughout an external promoter, and 57% during the assembly. Whereas in Jorullo, 24% of the respondents learned about it throughout an external promoter and 76% learned about it during the assembly (Figure 5.3).

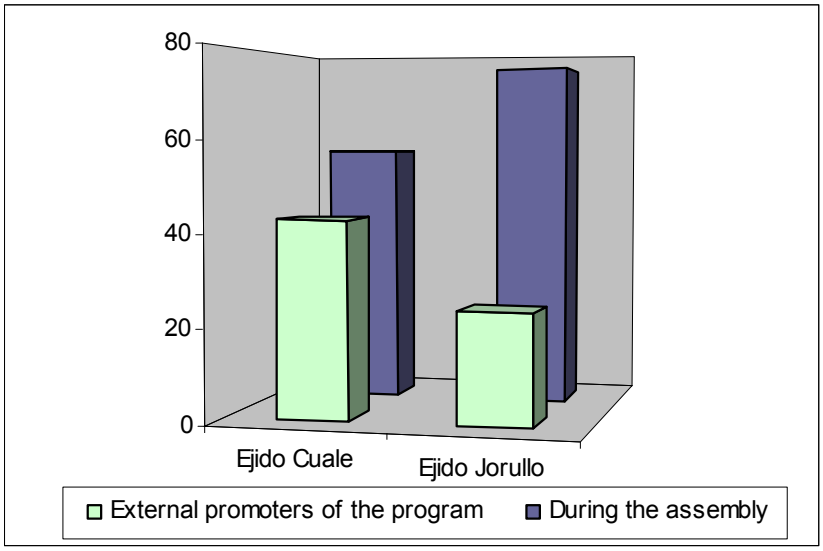

Figure 5.3 Percentage of landowners that learned about the PHS program either through an external promoter or during the assembly.

Attending the assembly meetings, which are performed once a month in each of the *ejidos* is problematic for those *ejidatarios* that live outside the *ejido*; thus, it is common to find *ejidatarios* who do not know about all the activities going on in the communal land. Concerning Cuale, Pearson correlation analysis showed a positive and significant correlation between living within the *ejido* and being informed about the program. ($r=0.316$, $p<0.05$), whereas no correlations between hearing about the program with gender or income ($r=0.052$, $p=0.744$; $r=0.065$, $p=0.681$ respectively) existed. These results suggest that knowing about the program is related with living within or outside the *ejido*, but not related with gender or income of participants; thus, migrants are less informed about the PHS program than local residents of Cuale.

Regarding Jorullo, the results showed no correlation between participants living outside the *ejido* and not being informed about the program ($r=0.61$, $p=0.728$). However, we found that knowing about the program is positively and significantly correlated with

gender (r=0.389, p<0.05), and with respondents income (r=0.347, p<0.05). Therefore, these results show, differently from Cuale, that male respondents with higher income are better informed about the program than women and participants with lower income, and that living within or outside the *ejido* is not determinant with being informed about the program. This suggests that although 26% of the *ejidatarios* live outside the ejido (in Puerto Vallarta), the majority of Jorullo landowners living in Puerto Vallarta attend the monthly assembly meetings. This situation is due to the proximity of Jorullo to the urban center, which is not possible in Cuale due to the large distances between the city and the rural localities.

Concerning Cuale, we asked the participants that were aware about the PHS program (67% of the totality of respondent) if they considered whether there was enough information available about the program, its function and guidelines. We found that only 17% of the respondents believe there was enough information, whereas 83% believe there was not enough information available (Figure 5.4). Moreover, the survey revealed that of those respondents that were aware of the program only 46% understood the real aim of PHS: preserving the forest cover in order to protect water recharge areas (Figure 5.5).

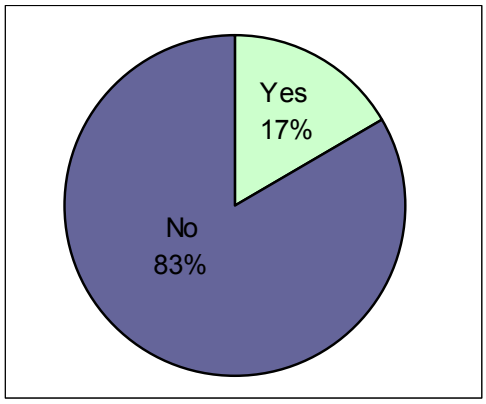

Figure 5.4 Percentage of *ejidatarios* from Cuale that believe there is enough information available about PHS.

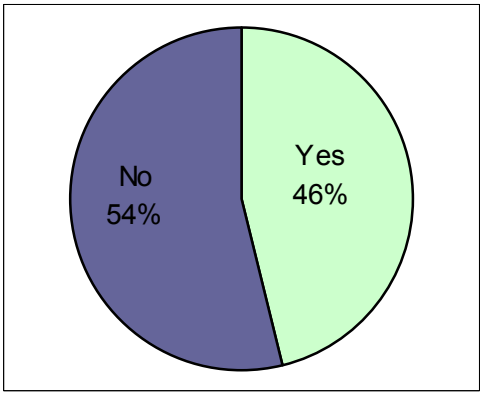

Figure 5.5 Percentage of *ejidatarios* from Cuale that understand the purpose of PHS.

Results showed a positive and significant correlation between considering there was enough information available about the PHS program in Cuale and performing forest harvesting as livelihood activity (r=.508, p<0.01), likewise understanding the purpose of

the PHS program and performing forest harvesting ($r=0.309$, $p<0.05$) (Table 5.1). This suggests that ejidatarios from Cuale that earn their living from the forestry enterprise were better informed about the PHS program than ejidatarios who perform agriculture, cattle ranching or charcoal production activities.

Table 5.1. Pearson's correlation between performing certain economic activities and understanding the purpose of the PHS program.

Correlations	Understanding the purpose of the program.
Agriculture	r=0.042 (p=0.793)
Cattle ranching	r=-0.253 (p=0.105)
Forest harvesting	r=0.309 (p=0.046)
Charcoal production	r=0.072 (p=0.651)

The statement above is explained by the presence of a forestry technician that fully informed the forestry workers of the *ejido* about the PHS program, whereas not much emphasis was put into informing the rest of the community.

In order to find out about the personal opinions regarding the PHS program, we asked if the participants of Cuale (the *ejido* where the PHS are currently operating) believed the program was a good option for protecting the forest cover. According to the survey, 31% of the respondents from Cuale said 'Yes', whereas 69% didn't know if the program was a good option for protecting the forest cover in the *ejido* (Figure 5.6). When asked about the perception of more land being cleared if they were not participating in the program, 19% of the respondents from Cuale said 'Yes', 10% responded 'No', and 71% don't know if by not participating in the program more land would be cleared (Figure 5.7).

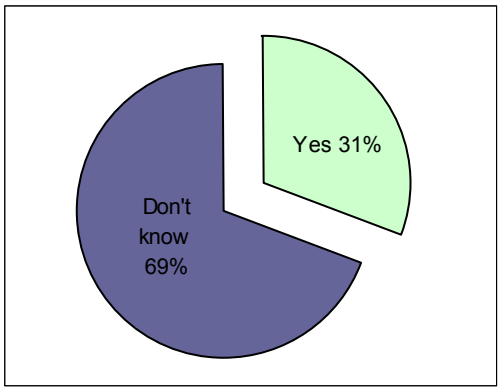

Fig 5.6. Percentage of landowners in Cuale that believe PHS is a good option for protecting the forest cover in the *ejido*.

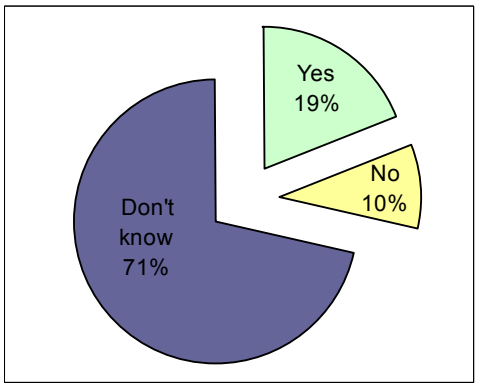

Fig 5.7 Percentage of landowners from Cuale that believe more land would be clear without PHS.

As shown above, the innovative approach of the PHS program has generated uncertainty among *ejidatarios*, who responded that they don't know how pertinent the program is, and who seem confused by the government's sudden interest, after decades of supporting productive agriculture and cattle-ranching activities, in protecting the forest cover.

The analysis showed that variables such as considering the PHS program as a good option for protecting the forest cover and believing there is enough information available about the PHS program are positive and significantly correlated ($r=.668$, $p<0.01$); suggesting that people who are appropriately informed believe the program is a good option to protect the forest cover, and according to our results these are individuals involved with forestry activities.

In addition to the environmental benefits, most of the landowners mentioned that the payments will also contribute to improving their wellbeing by bringing constant returns, which are certainly not high, but represent an important economic support to the communities. Among the benefits of the compensatory mechanisms, Ferraro (2001) stated that the payment itself is the primary benefit to poor communities, because cash flow in a community brings diversification of income and welfare, provides a stable income and reduces exposure to risk. As mentioned by Pagiola, *et. al.,* (2005b) and Ferraro (2001), unlike corn prices, the payments from a compensatory program do not oscillate from season to season, bringing stability and welfare to the households.

As described in Chapter III, the rural localities of the Rio Cuale watershed found in forests an important source of revenue, therefore when we asked if participants thought forests were valuable to the area, respondents of both *ejidos* in the watershed identified forests as valuable to the region (95% and 100% in Cuale and Jorullo respectively), either economically or culturally (Figure 5.8). And they stated that in order to preserve their communities' economic and cultural values, it was important to protect the forests in some way. Regarding the cultural value of forest cover, participants of both *ejidos* mentioned that forests provided recreational spaces, shade and food and attracted rain; whereas the economic values of forest cover were highly appreciated due to the provision of timber and of recreational spaces for ecotourism activities. Therefore, when asked if they were willing to protect the forest in their own land, 90% of respondents in Cuale and 100% in Jorullo said they were interested (Figure 5.9) and 95% of the respondents of Cuale stated that they would protect their forests even without participating in the PHS program.

According to the Cuale participants, they were interested in protecting the forest cover from eventualities such as forest fires and diseases, as well as from illegal woodcutters that annually diminish their timber stock. Respondents disclosed that nowadays they are fully aware that forestry provides better earnings than agriculture or cattle activities, therefore they are more interested in managing their forestry activities, thus avoiding clearings for agricultural purposes, and maintaining the remaining forests.

Despite the widespread interest in maintaining forest cover in Cuale, a few individuals (10%) pointed out their lack of interest about preserving the forest cover. The analysis showed that considering the forest valuable is negative and significantly correlated with the age of the respondents ($r=-0.362$, $p<0.05$), revealing that for the case of Cuale, the elderly are the respondents who do not believe the forests are valuable. Going deeper in the analysis, we found that these individuals are over 70 years old, had cattle as their primary economic activity, and inhabited Los Lobos locality, an area with high rates of deforestation in the watershed (see Chapter IV). Although they were not fully informed about the PHS program aim, they suggested that they did not agree with programs that limit cattle grazing, their only mean of subsistence.

On the other hand, participants from Jorullo revealed that they were also interested in protecting the forest from fires and wildlife poachers. They revealed that currently ecotourism activities are becoming an important portion of their earnings, providing higher revenues than agriculture or livestock; therefore, they are very concerned about protecting the forested recreational spaces. The income generated by the influx of tourists prompted a 'paradigm shift' in the use of natural resources in Jorullo, and according to the key interviews *ejidatarios* drastically change from performing slash and burn and other deleterious activities for the environment to a high degree of involvement in protecting forest cover and its fauna.

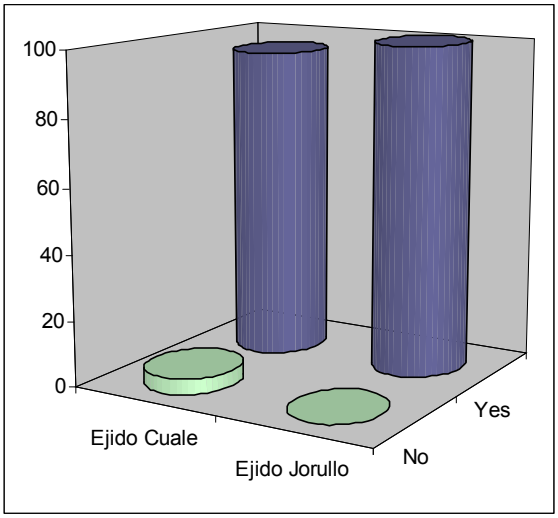

Figure 5.8 Percentage of *ejidatarios* from Cuale and Jorullo that believe forests are valuable to the area.

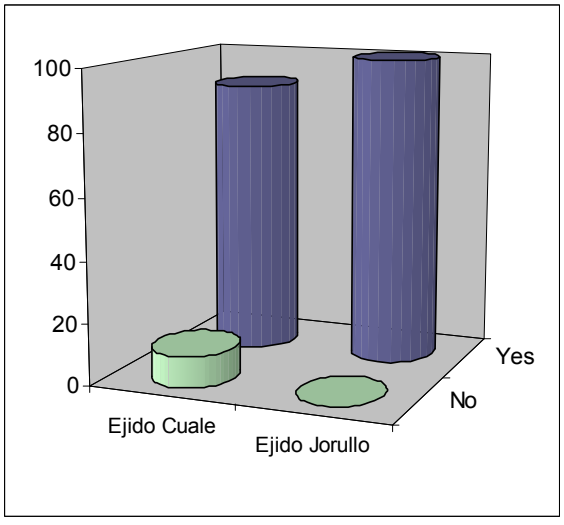

Figure5.9 Percentage of *ejidatarios* from Cuale and Jorullo that are willing to protect the forest in their own land.

5.3 'Payments' designated for collective land-use activities: forestry and ecotourism

In Cuale, key informants declared that, based on the PHS compensations (MEX $300 per hectare of temperate forest), the first year they joined the program the *ejido* received MXP $60,000, for the 200 hectares they designated for conservation. They also stated that the money from the PHS is being used for communal activities, mainly to support the communal forestry enterprise. According to them, the PHS earnings are being targeted to maintain saplings, pruning, fighting forest fires, and other forest related activities that were earlier being financed by the *ejidatarios* through a yearly allotment. According to the survey, most of the participants found it adequate to designate the PHS money to the communal forest enterprise, as it relieved them of the burden of paying that allotment. They also stated that it was convenient to support the forest enterprise, since it generated jobs that will benefit the community in the future. However, some respondents did not agree with the fact that the money was being designated to support communal forest enterprise (although the profits from the forestry enterprise are divided among the *ejidatarios*), and they wished that the payments could be used for activities such as garbage disposal within the localities. Moreover, some participants mentioned that instead of designating the payments for communal activities they preferred to divide the money amongst all *ejidatarios*.

In Jorullo, key informants stated that if their *ejido* could participate in the program, the *ejidatarios* were willing to designate the payments to a recently created communal ecotourism enterprise, which aims to preserve the forest cover for tourists' enjoyment. Therefore, as shown above, payments in Cuale are being designated for communal activities, and in the case of joining the program, Jorullo will follow this approach as well.

Designating the payments for communal activities is fair and appropriate due to the communal nature of land tenure in Mexico. According to Pagiola *et. al.* (2005b) in areas where land is owned commonly, decisions about enrolling in the program must be taken collectively, and the resulting costs and benefits from the program should be distributed

equally among the landowners. By allocating the payments to a communal forestry or ecotourism enterprise, the *ejidos* ensure that economic benefits will eventually be evenly distributed. In addition, the investment of the payments in the aforementioned communal activities denies the largely criticized conservation (or classic protectionism) approach of the PHS program. The Rio Cuale watershed provides evidence that synergies can be formed between forest management and payment mechanisms (Wunder, 2006).

CHAPTER VI. REVIEW OF FINDINGS AND CONCLUSIONS

This chapter presents a review of the research most important findings, as well as the overall conclusions of this work.

6.1 Review of findings

This study described the land-use changes in the Rio Cuale watershed during 1979-2002, using a combination of remote sensing techniques and tools of social inquiry. The proximate and underlying causes of land-use change were identified, and subsequently the efficacy of a conservation strategy based on monetary compensations was evaluated as promoter of forest cover preservation.

The Rio Cuale watershed is an important forested area in the west coast of Jalisco state, which directly supplies the water to Puerto Vallarta, a city with a high economic growth. The inhabitants of the two *ejidos* (Cuale and Jorullo) included in the watershed have traditionally performed rain-fed agriculture, growing mainly corn and introduced pastures. Corn crops in the watershed are mainly for subsistence, with an average cropping area of 4.99 hectares per inhabitant, whereas pasture fields are now being grown in larger scales in the lowlands of the watershed. Cattle ranching has also become an important economic activity in the region, with an average of 32 cows per landowner. Charcoal production and timber harvesting are activities only performed in Cuale, where inhabitants have extraction permits. In addition, landowners from both *ejidos* perform complementary economic activities to raise their income; in the case of Jorullo, those complementary activities are mainly in Puerto Vallarta. The study revealed that although in the past the farmers' livelihood was merely based on corn production and cattle ranching, today, off-farming activities are common in the watershed, representing a high proportion of the *ejidatarios* income. Livelihood diversification has caused differences in income distribution along the watershed, showing higher income in Jorullo due to its direct economic benefit from the tourist industry, and its possibility to engage in trade activities with the urban center.

Land-use change analysis revealed that from 1979 to 2002, the forest cover within the watershed increased 2.4% (639.96 hectares), with an annual rate of forest recovery of 37.88 ha/year for the period 1979-1990, and 14.29 ha/year for the period 1990-2002. Results showed that forest recovery was higher during the first eleven years of the study, and that Jorullo presented higher forest recovery rates in both periods than Cuale.

Throughout the survey and the key informants' interviews it was possible to discover the causes of this forest transition, which were categorized in proximate or direct and underlying or indirect drivers of change. Proximate causes of forest recovery were recognized as: the abandonment of agricultural fields by farmers who migrate to Puerto Vallarta, and the reduction in cropped surface caused by the current low corn prices. This abandonment of agricultural parcels and the reduction in cropped surface prompts growth of forest fallows and secondary forest, leading to a gradual recovery of the forest cover.

These proximate causes were driven by three context specific fundamental forces or underlying drivers of change: *i.* livelihood diversification, *ii.* local policies, and *iii.* rural-to-urban migration.

i. Livelihood diversification: reduction in corn prices due to intensification in certain areas of the country, and participation of Mexico in international trade agreements led to a decrease in viability of rain-fed agriculture performed in marginal lands. Thus, while decades ago one farmer would crop up to 20 hectares, nowadays that same farmer crops one or two hectares, finding it more profitable to buy cheap imported corn than produce it themselves. Decreasing in cropping activities encouraged an increase in livelihood diversification to maintain the family income, and at the same time, the high profits obtained from diversifying their livelihood has kept away farmers from continuing cropping.

ii. Local policies: *ejido* policies have been a crucial trigger of forest recovery in the watershed. Around a decade ago, the assemblies of both *ejidos* agreed to prohibit the clearing of forest for agriculture or any other purposes, stating that farmers should rely only on the agricultural fields they already possessed. In addition, they agreed that agricultural fields that were abandoned for more than 7 years and which yielded a

considerable re-growth of forest cover could not be further cleared for agriculture and should be left as part of the forested area of the *ejido*.

iii. Rural-to-urban migration: the increasing rural-to-urban migration presented in the watershed, prompted mainly by the lack of educational institutions and job opportunities, is revealed by a decline in the demographic curve within the watershed communities. However, instead of migrating to the United States as most of the rural communities in the country, farmers find in Puerto Vallarta an alternative to the American Dream, with a myriad of job opportunities and the possibility of earning US dollars. Therefore, the high migration rate of young labor force to Puerto Vallarta is causing a reduction in the cropped surface in the watershed. On the other hand, due to the proximity of Puerto Vallarta, migrants do not totally abandon their rural livelihood, as during the week-ends and holidays they usually return to their rural land, but they indeed reduce the cropped surface.

Based on the fact that it directly supplies water to the city of Puerto Vallarta, the Rio Cuale watershed was considered eligible to participate in a conservation oriented program based on monetary compensations launched by the Mexican Government. By the time of the interviews, only Cuale was participating is the PHS program, putting aside 200 hectares for strict conservation in the highlands of the watershed. Although Jorullo was not part of the program at that time, the farmers were willing to join the program and had already decided which land to put aside for conservation. We found these lands selected by both *ejidos* were not, in either case, suitable areas for agriculture or cattle ranching activities, due to remoteness and hilly topography. In the case of Cuale, the areas selected for conservation have historically been preserved by farmers due to the presence of natural springs that supply the localities, whereas farmers from Jorullo selected 'idle lands' to put aside, lands that have never been cropped and that cannot be sold due to its communal nature. As this research revealed, the areas selected for conservation were hardly going to lose their forest cover in the near future, and farmers were highly satisfied about getting profits from areas that before were not economically attractive.

The survey showed that although the PHS program has generated good acceptance among *ejidatarios,* there is a lack of information concerning the aim of the program, its guidelines and restrictions. However, those landowners who are well informed believe the PHS program is appropriate for protecting the forest cover in the watershed. Therefore, it is crucial to make larger efforts in informing all landowners, regardless of their age or economic activity, about the PHS program, in order to create a more homogenized opinion about forest protection.

Although the PHS program regulations do not state how the payments should be used, within the watershed both *ejidos* expressed their willingness to designate payments for communal activities that help maintain the forest cover. Concerning Cuale, the payments are currently being used to support the communal forestry enterprise, more specifically to maintain saplings, pruning, fighting forest fires, and other forest related activities that were earlier being financed by the *ejidatarios* through a yearly allotment. With reference to Jorullo, key informants stated that the willingness to participate in the program is to designate the payments to the communal ecotourism enterprise recently created, which aims to preserve the forest cover for tourists' enjoyment.

6.2 Conclusions

Mexico is considered to have one of the highest rates of deforestation in the world; however, recent studies have shown that despite the alarming rates of forest cover loss, some areas are presenting what Mather (1992) called a forest transition. The results of this study showed that the Rio Cuale watershed presents this recovery process, due to direct causes such as the abandonment of agricultural fields and the reduction in cropped surface that promote tree re-growth in the abandoned parcels. At the same time these direct causes of change are triggered by context-specific underling causes such as livelihood diversification, local policies and rural-to-urban migration. As stated by Klooster (2003), the non-frontier regions in Mexico are suitable areas for forest transition to take place; however, it is unlikely to find this trend at the national level in developing countries (Rudel, 1998).

Despite the negative rates of deforestation, part of the landowners of the Rio Cuale watershed joined, in 2005, a conservation mechanism based in monetary compensations called Payment for Hydrological Services. This mechanism has been widely criticized as a conservation tool due to its protectionism approach, which according to some authors, encourages landowners to leave their rural activities, as they cannot further manage the forest, bringing negative long-term consequences to the environment. However, this study suggests that, for the specific case of the Rio Cuale watershed, by voluntarily targeting the payments to forest management activities, such as forestry in the case of Cuale and ecotourism in Jorullo, the payments are contributing to the creation of jobs, suggesting a promising rise in the farmers' wellbeing, and are achieving the main goal of the program: helping to maintain the forest cover in the watershed, thus contributing to preserving water recharge zones. Therefore, this study implies that under the present conditions, the PHS program may reinforce the trend of forest recovery that started decades ago due to the economic demography of the watershed.

Although nowadays the watershed does not present ecosystem loss, the land speculations due to the growing economic rates of Puerto Vallarta may represent a future threat to the watershed's ecosystems and the services they provide. However, according to the positive experience of the PHS in the watershed, it is possible to create long-lasting compensatory mechanisms that will guarantee the conservation of the forest cover by involving the society members, creating local mechanisms between upstream landowners (*ejidatarios*) and downstream direct water users (Puerto Vallarta citizens), instead of having the government as the primary payer of the service.

Payment for ecosystem services is not a universal remedy (Rosa *et. al.,* 2004) nor a silver bullet (Landell-Mill & Porras, 2002), but an efficient tool that, under the right conditions, can induce changes to land uses which then can maintain ecosystem services (Pagiola *et. al.*, 2005).

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APPENDIX I. SURVEY INSTRUMENT

Questionnaire outline Rio Cuale Watershed

Participant No. Date:

Age:

Gender:

Part I. General information

1. **Do you live within the Ejido?**

   Yes_____ No_____

2. **What type of economic activities do you perform within your private or communal land?**

   Agriculture _____

   Cattle ranching _____

   Other, specify _____

Agriculture:

3. **What type of crop do you grow? (specify the number of hectares for each)**

   Corn_____ No. of hectares _____

   Other, specify_____ No. of hectares _____

4. **How long have you been farming?**

   _____ Years

5. **Do you produce enough to meet your personal needs?**

   Yes_____ No_____

6. **If yes, do you produce enough to sell in the market?**

   Yes_____ No_____

7. **If yes, where do you sell it?**

Neighbor localities_____ Guadalajara _____

Puerto Vallarta _____ Other, specify _____

Cattle ranching:

8. **What type of livestock do you have? (Please, specify the number of animals that you own)**

   Cow _____ Chicken _____

   Goat _____ Other, specify _____

   Pork _____

9. **Are cattle activities profitable for you?**

   Yes_____ No_____

10. **Where do you sell the products of your cattle activities (meet, milk and others)?**

    Neighbor localities_____ Guadalajara _____

    Puerto Vallarta _____ Other, specify _____

11. **Do you perform any other economical activity within the Ejido?**

    Yes_____ No_____

12. **If yes, what type of activity?**

_____

13. **Do you perform any other economical activity outside the Ejido?**

    Yes_____ No_____

14. **If yes, what type of activity?**

_____

15. **Do you receive remises from family members that live outside the Ejido?**

    Yes_____ No_____

16. **What is your monthly income?**

    Less than 1,000 pesos_____

    Between 1,000 and 3,000 pesos_____

    Between 3,000 and 10,000_____

    More than 10,000 _____

Part II. Land-use Change

17. Do you use the forest in the communal property for any purpose?

Yes_____ No_____

18. For what purpose?

_____

19. Have you seen any land-use changes in the communal parcels since 1970?

Yes_____ No_____

20. If yes, what type of land-use changes have you seen? (please use the visual aids: aerial photos, maps, satellite images)

_____

21. In your opinion, why have these land-use changes occurred?

_____

22. Are you planning to expand your farm (clear forest) for agriculture or cattle ranching in the next five years?

Yes_____ No_____

23. If yes, where will you expand?

_____

24. If yes, why would you expand?

_____

25. Has the tourist industry from Puerto Vallarta affected the economy or social activities of the Ejido?

Yes_____ No_____

26. If yes, in which way has the tourist industry done so?

_____

27. Has the tourist industry from Puerto Vallarta affected the conservation of the natural resources of the Ejido?

Yes_____ No_____

28. If yes, in which way has the tourist industry affected the conservation of the natural resources of the Ejido?

_____

29. Do you beneficiate from the tourist industry?

Yes_____ No_____

30. What do you think are the most important environmental problems within the Ejido?

_____

Part III. Ecosystem services

(The following questions will be asked to landowners of the Ejido Cuale).

1. **Have you heard about the Payment for Environmental Services Program that the Federal Government created?**

_____

2. **How did you learn about the Program?**

_____

3. **Is there good information available about how the Program works?**

Yes_____ No_____

4. **What do you understand is the purpose of the Program?**

_____

5. **Do you think the Program is a good option for protecting the forested land in the Ejido?**

Yes_____ No_____

6. **If you were not participating in the Program, do you think more land would be cleared?**

Yes_____ No_____

7. **Do you think that forests are valuable to the area?**

Yes_____ No_____

8. **Do you want to protect the forest on your own land?**

Yes_____ No_____

9. **Would you do so without participating in the Program?**

Yes_____ No_____

10. **Do you know that by protecting the forest in your Ejido, you protect the Rio Cuale flow which supplies Puerto Vallarta City?**

Yes_____ No_____

(The following questions will be asked to landowners of the Ejido El Jorullo).

1. **Have you heard about the Payment for Environmental Services Program that the Federal Government created?**

   Yes_____ No_____

2. **If yes, how did you hear about the Program?**

_____

3. **Why is the Ejido not participating in that Program?**

_____

4. **Would you have liked to participate in the Program?**

   Yes_____ No_____

5. **If yes, why would you have liked to participate?**

_____

6. **Do you think that forests are valuable to the area?**

   Yes_____ No_____

7. **Do you want to protect the forest on your own land?**

   Yes_____ No_____

8. **Do you know that by protecting the forest in your Ejido, you protect the Rio Cuale flow which supplies Puerto Vallarta City?**

   Yes_____ No_____

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Certificate of Ethical Acceptability of Research Involving Humans

REB File #: 158-0405

Project Title: Trends of the Rio Cuale flow based on different land use scenarios of the upper watershed

Applicant's Name: Paola Bauche **Department:** Geography

Status: Master's student **Supervisor:** Prof. R. Sengupta

Granting Agency and Title (if applicable): Consejo Nacional de Ciencia y Tecnologia (CONACYT)

This project was reviewed on 6 April, 2005 by

Expedited Review ✓
Full Review ____

John Galaty, Ph.D.
Chair, REB I

Approval Period: April 20, 2005 **to** April 19, 2006

This project was reviewed and approved in accordance with the requirements of the McGill University Policy on the Ethical Conduct of Research Involving Human Subjects and with the Tri-Council Policy Statement on the Ethical Conduct for Research Involving Human Subjects

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*All research involving human subjects requires review on an annual basis. A Request for Renewal form should be submitted at least one month before the above expiry date.
*If a project has been completed or terminated and ethics approval is no longer required, a Final Report form must be submitted.
*Should any modification or other unanticipated development occur before the next required review, the REB must be informed and any modification can't be initiated until approval is received.

cc: Prof. R. Sengupta