REASSESSING FOREST TRANSITION THEORY:

GENDER, LAND TENURE INSECURITY AND FOREST COVER CHANGE

IN RURAL EL SALVADOR

by

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ABSTRACT OF THE DISSERTATION

Reassessing Forest Transition Theory:

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Rural out-migration, increasing market orientation and forest resource scarcity, according to the forest transition theory, promote the recovery of forests on landscapes in rural areas. However, the drivers and paths in the North American and European case studies, on which the theory was developed, differ in important ways from those drivers and paths observed in case studies conducted in the tropics. The forest transition theory, through a feminist lens, is reassessed by examining the social drivers of forest cover change in a case study in El Salvador. A gender sensitive construction of forest transition theory incorporates the ways in which the social and cultural roles of women interact with migration patterns, land tenure structures, and organizations, such as cooperatives. The results of qualitative research conducted in El Salvador (2005-2007) at the household level and of quantitative research at the regional and national levels demonstrate that ecological processes of forest recovery, through a confluence of factors, have an important, heretofore unrecognized gendered dimension.

Preface

This dissertation is the result of fieldwork conducted in El Salvador and analyses conducted in the United States between May 2005 and January 2009. However, the motivation for undertaking such a project has a much deeper history. As an undergraduate and graduate student of environmental policy and economics at Boston University, I was continually frustrated by the apparent disconnect between policy that was either aimed at conserving resources or exploiting them and the people most affected by their implementation. A second frustration I have had is the apparent disregard for the women whose voices have often been silenced in conservation and/or development of natural resources. This dissertation is written principally for practitioners of environmental policy and for the women seeking their voices in this process. And while it was never intended in this way, this dissertation is especially written in memory of one, forever-silenced, woman in particular.

My field work was abruptly suspended in a way that I never could have anticipated. Shortly after completing interviews in El Tigre, my longtime hostess in El Salvador, Francisca Carolina Canizález de López, was kidnapped and murdered in a most heinous act of violence that robbed her children, granddaughter, family, friends, and all who loved and adored her of a strong, independent, intelligent and loving woman. She truly lived for those she loved. I feel privileged to have known her and her love. I will always remember how she took me into her home, without having ever met me, and welcomed me as her prima. I am so grateful for all the happy memories she created for us all. Without her, this project would not have been possible, and yet now, without her, this project remains incomplete without one of its greatest advocates.

Dedication

To my mother, Karen, with deepest love and affection, for your unfailing support and guidance. I love you, my buddy.

To my Lito, for your patience and understanding. Te quiero mucho, mi amor.

Hoy yo canto en recuerdo de ti, Pachi.

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To the people in El Salvador who were kind enough to help me at various stages of the research, I could not have done this without you. The many people of El Tigre were incredible to welcome me into their homes and offer me a glimpse into their lives.

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All throughout my graduate career, I have relied on the expertise of many people. Teresa Delcorso, in particular, was a great mentor and friend. Betty Ann Abbatemarco, Rosanne Vacarro, Michelle Martel, Elaine Gordon, Mike Siegel, and Elana Broch (Princeton University) helped me with mountains of paperwork, negotiated budget procedure I couldn't possibly hope to know, fixed broken printers, issued new keys when I lost them more than once, uncovered the mysteries of ArcGIS, and navigated the wonders of Salvadoran archives, respectively. And yet, this only scratches the surface. Za Barron, Adam Pine, Angel Ling, Ben Neimark, and Gwangyong Choi have been exceptionally, wonderful colleagues and friends at Rutgers.

I have had amazing friends and family to help me stay grounded. Patricia Kalber, Bob Kalber, Shirley Reeves, Jesse Kellow, Harry Kellow, Linda Kellow, Harris Zambrana, Dolores and Jorge Santos, Maria Santos, Megan Simpson, Ron Simpson, Kate Simpson, and Michelle Tunney all have special places in my heart. I am forever thankful to have you in my life always.

My parents, Karen and Tom Simpson, have been my greatest advocates. Thank you for your constant love and patience. I love you both so much. I consider myself

incredibly lucky to have such intelligent, funny, and caring individuals as my parents. This was genuinely a collaborative achievement that would not have been possible without you. You will forever share this with me.

Carlos O. Santos, my brilliant husband, is a tremendous gift in my life. Without his emotional strength and his courage to take a chance on this adventure, I would not be where I am today. Today, we share this joy. I look forward to reaching for many more of our dreams together. I love you.

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Chapter I: Introduction and Framework

Research on the drivers and science of land change has accelerated recently in response to widespread concerns about the negative environmental costs of deforestation (Watson et al. 2000; Kalnay and Cai 2003; Turner et al. 2003). Forest expansions and recoveries are of interest for the essential ecosystem services provided, the timber and non-timber commodities produced, and the world's water and carbon cycles regulated (Steffen et al. 2004).

Some have observed international policy debates that describe forests as "global" common resources, despite being under sovereign control of independent countries, because of their "global" environmental goods (i.e. biodiversity and carbon sequestration) (Vogt et al. 2007). The international community may be viewed as having a shared responsibility to prevent independent and sovereign countries from allowing the global forest commons to be depleted by the economic interests of businesses and individuals therein, since tropical old growth forests are the most effective carbon sink of all landscapes. For some, the only way to ensure that old-growth forests and resurgent secondary forests are protected is via government, or sometimes international government, intervention (Terborgh 1999). However, the failure of "fortress conservation" schemes (Curran et al. 2004), in some instances, implies that the drivers of both deforestation and reforestation are complex and multifaceted, and further, policy prescriptions for forest conservation may not be universal.

According to the Millennium Ecosystem Assessment, "deforestation in the tropics occurred at an average rate exceeding 12 million hectares per year over the past two decades…[and]…the global area of temperate forest increased by almost 3 million hectares per year" from 1990 to 2000 (Millennium Ecosystem Assessment 2005). Yet, the global assessment misses the point that, on regional and local levels, several studies suggest that forest resurgence is outpacing forest loss in some tropical forests.

Researchers have recently documented forest recovery and expansion in places previously dominated by net deforestation and contraction. The observations of forest recovery are present in Central America (Hecht et al. 2006; Klooster 2000; Southworth and Tucker 2001), the Caribbean (Grau et al. 2003), South America (Perz and Skole 2003), and South Asia (Foster and Rosenzweig 2003). The reports of continued deforestation and emerging reforestation reveal the overwhelming need, but tremendous challenge, to understand the dynamic relationships between people and forests.

The recent claims that forest recovery is occurring in the tropics depends on the accurate aggregation of national and subnational case studies. The limitations of such studies and the aggregation of results from disparate methodologies may cause researchers to overlook important drivers of forest recovery that occur at scales of analyses beyond the national and sub-national levels (Perz 2007). Still, explaining forest recovery, without over-generalizing or becoming too context-specific, presents challenges. Because variables work at multiple scales and have complex impacts, researchers are tasked with developing better and mixed methods for studying people-forest dynamics at multiple temporal and spatial scales (Ostrom and Nagendra 2006). The expectation is that, through these studies, the drivers of forest contractions and expansions and relationships between local communities and forests will be better understood, and that the institutions for promoting forest expansion and conservation consider those drivers and relationships.

Extensive and longstanding research is committed to understanding the drivers of forest contraction; however, explanations for the drivers of forest expansion and recovery are still emerging (Lambin et al. 2001). The forest transition theory is one such explanation of the sudden shift from net deforestation and forest contraction to net reforestation and forest expansion. Forest transition theory, a geographical model based on case studies of forestation in the United States and Europe, states that deforestation stops at a critical point in a country's economic development, and land then reverts to forest (Mather 1992; Mather and Needle 1998). Applying the forest transition theory to the tropics, today, may be problematic in that the socio-economic and geographical correlates of reforestation in the tropics may not resemble the correlates of similar changes in forest cover in temperate climates.

The question of how and why a forest reaches a turning point has been recognized as critical and timely (Kates 1987), as primary forests are continually lost. The call to better understand the origins of the turning point in a country's forests is important as forests, at the global scale, are still experiencing net deforestation. Identification of the drivers may prove useful in hastening a global turning point to forest recovery and expansion. Moreover, those forests that have already begun to recover in the presence of human settlement and without government intervention may provide useful insight for making resource management decisions elsewhere.

Human-environment research is not new in geography, but since at least the mid-1800s (Marsh 1898), human activities have become the central focus of studies in understanding how the earth surface changes. The ability of humans to alter the landscape at the local and regional scale is well established (Sauer 1956; Thomas 1956). However, the recognition that humans, more than natural forces, are responsible for global environmental changes, too, has resulted in geographic study focused on modeling the social forces of human behavior to make predictions about future environmental change (Turner and Meyer 1994). Robert Kates, Billie Lee Turner II and others have argued that it is the accumulation of transformations at the local and regional scales that have led to the escalation of the human impact on the earth over time and resulted in a shift in scale from the local to the global (Turner et al. 1991). Such research that examines human dimensions of environmental change at multiple scales crosses disciplinary boundaries and requires scholars to examine biophysical and social drivers of land change (Steffen et al. 2004). Studies in human dimensions of environmental change increasingly call for scholars to employ multiple-methods analyses of political-ecological processes to interpret social and environmental changes (Zimmerer and Bassett 2003).

Understanding land transformations or land transitions in human-environment systems, usually describes research on land use and land cover change (Comber and Fisher 2005). Landscapes, covered by a particular physical material and used by humans in specific ways, are influenced by histories, social and economic conditions, and ecologies (Foley et al. 2005); and as such land systems can be described as coupled human-environment systems that address the interdependence explicitly (Folke et al. 2002). Land use more often denotes the social dynamics occurring on the earth surface (i.e. settlement, cultivation). Land use change, then, refers to a conversion from one human activity to another (i.e. from cultivation to settlement) or a change in intensity of one use (low density settlement to high density settlement). Land cover denotes the physical properties of the earth surface (i.e. forest, grassland, water). Land cover change also refers to either a conversion from one land cover type to another (i.e. forest to grassland) or a modification within one land cover type (i.e. dense forest to thinned forest). Yet, it is the integrated approach of examining land systems that incorporates both the social and biophysical that is garnering greater attention in recent years (Turner, Moran, and Rindfuss 2005). Land use changes are marked by political, social, and economic changes, inequities, and conflicts between different groups of people occupying the landscape (Kates and Parris 2003).

Forest transition theory explains the connections between forest cover change and economic development at the national scale. Because of the limitations of data availability, forest transition studies do not typically address the more regional and local dynamics of forest expansion and contraction. The model, based on observations of recoveries of temperate forests, has been applied more recently to the tropics, despite differences in the context of economic development conditions of countries in the tropics compared to the earlier examples.

Recently, forest recovery has been observed in El Salvador. As a response to the resurgence of forests and pressures from outside agencies, the Salvadoran government has adopted policies that are aimed at conserving the returning forests. After all, forest resurgence is extremely beneficial in the context where deforestation contributes each year to flooding, landslides, and outbreaks of dengue fever from thriving mosquito populations. Conservation policies, while important for protecting environmental services, may evict rural people, particularly women (who are relatively land poor), from lands on which they depend (Gibson 2001; Gibson, Lahoucq, and Williams 2002; Larson 2002). Since deforestation is viewed as the problem, the perception of that problem is extended to encompass poor rural people who are responsible for degradation of the environment. The legislation accepts that enclosing the 'commons' is the best policy solution in response to a perceived threat (Doos 2002; Ehrlich 1971) of a growing rural population and the rural poor's demands on forest and land resources. These policies reflect the assumption that rural dwellers are no longer relying on reforesting lands for livelihoods. Campesinos in rural areas have little to no input in the decisions about how to manage the protected lands, and subsequently, are being excluded from the land and silenced in their potential contribution to the development of forest policies (Gammage, Benitez, and Machado 2002). As several international agencies work to physically connect protected areas across Central American countries in the Mesoamerican Biological Corridor,[1] understanding the driving forces of the forest transition becomes more critical since increasing forests may potentially introduce new vulnerabilities for those with little power in rural societies.

This dissertation reassesses the forest transition theory, through a feminist lens, by examining the social drivers of forest cover change in a case study in El Salvador. A gender sensitive construction of forest transition theory incorporates the ways in which the social and cultural roles of women interact with migration patterns, land tenure

[1] The Mesoamerican Biological Corridor is considered an Integrated Conservation and Development Project funded and/or supported by the Central American Commission for Environment and Development, United Nations Development Programme, United Nations Environment Programme, World Bank, the German Technical Cooperation Agency, and others and via the cooperation of the governments of Mexico, Belize, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, and Panama (Lopez and Jimenez 2007).

structures, and organizations (i.e. cooperatives) to influence land use and land cover change.

El Salvador provides an excellent context to study national, regional, and local patterns of forest contraction and expansion. In particular, El Salvador has a record for extensive forest degradation and destruction, which raises questions about the drivers of forest change in reports of recent forest resurgence. Moreover, El Salvador is attractive as a case study for its cultural and racial homogeneity in rural areas and recognized regional differences with regard to remittance economies, agricultural crops, and history of impact by civil conflict.

Political factors have played an important role in structuring the context in which forest cover change has occurred. The civil war of the 1980s resulted in dramatic out-migration from El Salvador's rural areas, as campesinos were frequently targeted in the fighting. The migrations to urban areas in El Salvador and abroad have subsequently resulted in an increase in the flows of remittances to rural areas in El Salvador, most affected by the civil conflict.

The Salvadoran agrarian reforms of the 1970s, 1980s, and 1990s resulted in the breaking up of large parcels in a land-to-the-tiller arrangement. The aim was to increase small-holder and peasant access to land. The result was a regionalization of land ownership regimes, highly correlated with history of civil conflict (i.e. land was less likely to be titled or in-process of becoming titled in areas where people were most affected by the civil conflict). In some cases, women's access to land was decreased after the reforms. The land reforms did not challenge gender roles and the gendered division of labor. The gendered division of labor and control of land was, and is today, accompanied by highly gendered notions of geographical space (i.e. women in the home, not on the farm).

While it does not dictate a particular methodology, forest transition theory has been the impetus for several studies that examine forest cover change from global to local scales. Recent research has begun to explore how the combination of remote sensing and ethnographic methods may be utilized to better interpret the data collected by any one methodology alone for the purposes of human-environment geographic inquiry (Fox et al. 2003; Lambin et al. 2001; Liverman et al. 1998). The mixed methods approach of combining remote sensing and ethnographic methods is still relatively new. As such, there are few guidelines that establish an accepted or standard technique for conducting research of this kind. However, a critical assessment of which individual methodologies most appropriate to yield the data of interest in the most effective and efficient manner shows that a mixed methods approach is arguably required here.

Designing the research in the mixed methods approach has several advantages. The incorporation of household-level land use decision making helps to uncover the drivers of observed biophysical changes. While remote sensing analysis may be an excellent choice for observing such biophysical changes, remote sensing does not capture all of the drivers of such change. Social drivers, such as gendered property rights, migration patterns, and remittance incomes in household decisions concerning land management, are more readily quantifiable via household interviews. El Salvador provides a context for the mixed approach to the study as census-derived data is readily available, and El Salvador’s National Registry provides rich spatial data sets.

The investigation of gendered land use, migration, and forest cover change was undertaken in two phases. In the first phase, ethnographic interviews were conducted among households in Cantón El Tigre in the municipality and department of Ahuachapán (see Figure 1.1) and among key informants in San Salvador, El Salvador in 2005 and 2007.

Figure 1.1. Cantón El Tigre and departmental divisions of El Salvador. Map by Jessica J. Kelly.

The case study of Cantón El Tigre is representative of an apparent anomaly in forest transition, since Cantón El Tigre and much of western El Salvador has exhibited forest recovery and little out-migration. As such, Cantón El Tigre represents a potentially crucial case in assessing the degree to which forest transition theory in its original formulation is appropriate for El Salvador altogether. Since according to the theory, one should not expect to see forest recovery in a place where population density remains high in rural areas and where agriculture is still an important economic activity there. Yet according to national studies, forest recovery appears to be occurring here and in other high-density, rural areas of El Salvador (Hecht and Saatchi 2007). The aim of the first part of the study, then, is to understand land use decisions in relation to forest recovery in a place where forest recovery would not ordinarily be expected according to the theory.

In the second phase, time-series remotely sensed images of high spatial resolution were analyzed to assess the extent of forest recovery at the local scale of the municipality of Ahuachapán (including Cantón El Tigre). In addition, a set of remotely sensed images (coarse spatial resolution) and national census data were analyzed to assess regional patterns of forest cover change and the relationship with socio-economic conditions in municipalities. Typically, four regions or zones are recognized in El Salvador (DIGESTYC); these zones will be used to describe trends and patterns in El Salvador until chapter five where an alternative regionalization is offered (see Figure 1.2).

Figure 1.2. Zones of El Salvador. Map by Jessica J. Kelly.

The dissertation is divided into six chapters beyond the introduction. Chapter two is a theoretical discussion of the foundations, extensions and applications of forest transition theory. The chapter includes a deconstruction of the theory as presented by Alexander Mather and others, the application of the theory to the case of the tropics, a critique of the assumptions made and an introduction of the significance of gendered land tenure and migration as significant in analyzing forest cover change in the tropics.

Chapter three reviews the contextual conditions in El Salvador for the historical underpinnings of civil conflict in response to unequal land distribution and the implications of that history for migration patterns, today's tenurial arrangements, women's access to land, the development of a remittance economy, and the changes to the economic and social landscape after the war. The chapter also discusses observed forest change since the conclusion of the war, as well as the possible scenarios for regional forest cover change in El Salvador.

Chapters four, five and six use diverse methodologies to explore forest transition theory's application in El Salvador at different scales. The results of the multiple methods employed to examine the social drivers of forest cover change in El Salvador are examined for El Salvador, nationally, regionally, and locally. Chapter four examines forest cover change in the municipality of Ahuachapán, using several different methods for analysis of remotely sensed imagery. The analysis establishes the biophysical changes at the local level. Chapter five presents the results of multivariate analysis of municipal-level census data and forest cover change to discuss regional trends in forest cover change and the gendered drivers of such change. Chapter six presents the case study from El Tigre. There, I examine observable differences in collective and individual land use decision-making along gender lines.

The concluding chapter, chapter seven, discusses the implications of including several variables and scales of analysis to interpret findings on forest cover change and management decisions based on these analyses.

Chapter II: Women, Property Rights and Migration in Secondary Forests: Theorizing Forest Expansion and Recovery in the Tropics

Introduction

Researchers seeking explanations for forest recovery and expansion in the tropics have looked to past observations of forest recovery and expansion in the temperate forests of the North. However, models of forest recovery may not be so easily applied to developing countries as the contextual conditions of development appear to differ in important aspects. Here, an examination of the forest transition theory provides a useful foundation for understanding forest cover change in temperate forests. The forest transition theory is applied to the tropics, where the theory reveals some of its shortcomings. In accounting for differences across gendered land use decision-making, property rights and migration, tropical forest recovery does not follow the model of forest transition as precisely.

I. Forest Transition Theory: Reforestation in Temperate and Tropical Forests

Forest transition theory, a geographical model based on historical case studies of forestation in the United States and several European countries, states that net deforestation and forest contraction stops at a critical point in a country's economic development, and then forests expand (Mather 1992; Mather and Needle 1998). Forest cover change, then, follows a U-shaped curve. For the early theorizers of forest transition theory, the question is ultimately whether the observations of forest recovery and expansion in temperate forests could be used to explain forest transitions in tropical forests, suggesting that the same drivers and conditions surrounding national-level forest expansion in the temperate forests of the developed North exist for the tropical forests of the developing South. The forest transition theory has been demonstrated by several cases in the developed world context, such as the United States, Portugal, and Denmark, among others (Grainger 1995; Rudel 1998; Mather and Needle 1999; Mather 1993).

According to Alexander S. Mather, the proximate causes for forest recovery and expansion vary from developed country to developed country, but he identifies three major factors responsible for the transition: demands for forest products and services, population trends, and resource values and perceptions (Mather 1992), with the later two being most significant for prompting the forest transition. In examining population trends, evidence suggests that with increasing rates of population growth and the corresponding expansion of agricultural production, forests decline. However, stabilization of forest areas or forest recovery has often preceded population stabilization and sometimes recovery has occurred in times of renewed population growth. Still, Mather observes that countries with high rates of population growth correlate with high rates of deforestation, and countries with stable populations correlate with expanding forests (Mather 1993). Complicating factors include the extent of urbanization, national land policy, and trading policies and patterns. He writes, “avoidance of land reform or the displacement of traditional cultivators by commercial, export-oriented agriculture may lead inexorably to forest colonization and clearance in some countries” (Mather 1992).

And while the turning point may be abrupt or stretch over centuries (Grainger 1995), Mather later identified the importance of progressive adjustment of agriculture to land capability as being the underlying conditions responsible for the allowance of a turn in net forestation (Mather and Needle 1998). While population rates may still trend positively, agricultural production is concentrated on the best lands suited to agriculture, allowing the more marginal lands to return to forest. The theory then predicts that modernized agricultural development and urban employment opportunities would result in spatially concentrated areas of reforestation or uneven patterns of reforestation. Building on the earlier conceptualizations of forest transition theory, two paths are identified for forest recovery: the economic development path and the forest scarcity path (Rudel et al. 2005). Reforestation may occur along either one or a combination of both paths.

According to the economic development path of forest transition, poor farmers leave the rural land to find employment in secondary and tertiary employment in urban centers. Rural-to-urban migration, thus, allows for an increase in forest cover on the rural landscape as rural land is released from agricultural uses. Furthermore, as market orientation increases, subsistence farming declines. Agricultural intensification is accompanied by increasing spatial concentration of labor and capital in the best land available and by a decreasing spatial concentration of labor and capital in the most marginal land. Thus, forests are left to return or recover in the abandoned, poorer, more marginal land. In this case, a formal, national afforestation policy is not necessarily adopted to increase forest expansion and recovery. At more advanced stages of economic development, population growth declines, a service economy emerges, and the demand for environmental quality increases (Skole 2003).

According to the forest scarcity path of the forest transition theory, increases in demand for forest products in a newly industrializing country may result in efforts, both publicly and privately, to restore forests intentionally. Here, a formal, national afforestation policy is typically accompanied, though not necessary. A forest transition also occurs, following the resource scarcity path, when the value of forest products increases and scarcity of that resource prompts governments or landholders to plant trees (Rudel et al. 2005).

Mather identifies the popular discourse during the nineteenth century in eastern United States and parts of Western Europe as one of fear about deforestation. These fears, are not dissimilar to those expressed today about deforestation in the tropics (Mather 1993). The timing and form of such transitions varied across the case studies, but Mather suggests that the underlying trends of economic development, population, resource perception, and political climate are significant in driving the forest transition. Forest transition theory suggests that tropical deforestation will at some point stop and forests will expand, as was true for the United States and Europe. However, the conditions under which the transition occurs in developing countries may be very different that the conditions observed in developed countries (Rudel, Bates, and Machinguiashi 2002).

Forest recovery and expansion have been recently documented in countries previously dominated by net deforestation and contraction. Local observations of forest recovery in Central America (Hecht et al. 2006; Klooster 2003; Southworth and Tucker 2001), the Caribbean (Grau et al. 2003; Rudel and Perez-Lugo 2000), South America (Perz and Skole 2003; Rudel, Bates, and Machinguiashi 2002), and South Asia (Foster and Rosenzweig 2003) suggests that forest transitions may now be underway in tropical countries. Some scholars have suggested that policy ought to be aimed at preparing migrants for jobs in cities and at promoting ecosystem recovery in abandoned agricultural lands (Aide and Grau 2004). However, such policies reassert the assumption that conditions in the tropics are similar to those previously observed in the developed world or that a mass rural exodus takes place and agricultural lands are abandoned when an economy becomes increasingly industrialized.

The impacts of political instability, globalization (Hecht and Saatchi 2007), natural disasters, structural adjustment programs (Escobar 1995), democratization, decentralization (Gibson and Lahoucq 2003), changes in the demographic structure (Doos 2002), changes in environmental ideologies, national policies (Rasul, Thapa, and Zoebisch 2004), infrastructure development (Perz et al. 2007), and international trade agreements have all played important roles in the individual forest recoveries within independent countries in the tropics in ways that were not observed in the temperate forests of the United States and Europe. From both top-down and bottom-up, the contextual conditions associated with forest recovery in developing countries would appear to differ in important respects from the histories of landscape change in Europe and the United States.

II. Hypotheses

To examine whether forest transition may be applied in the tropics, several hypotheses emerge as they relate to three key variables that were otherwise assumed by the original formulation of the theory. They include: land tenure, gender of head of household, and remittance incomes. The local contextual differences for forest recovery in the tropics suggest the following hypotheses.

Hypothesis 1. Forest transition is occurring as predicted by the theory. With remittance income arriving, male and female heads of household allow land to revert to forest. Alternatively, population declines attributable to out-migration would cause increased land abandonment and reforestation.

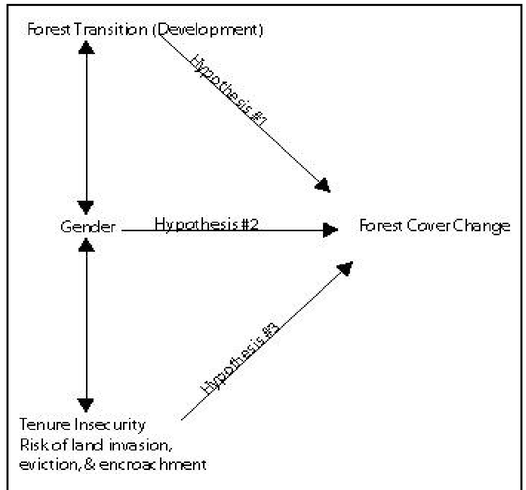

Figure 2.1. Social drivers of forest cover change.

Hypothesis 2. Rate of reforestation on occupied land is correlated with head of household gender with women being less likely to allow reforestation.

Hypothesis 3. Rate of reforestation on occupied land is correlated with the status of land tenure and the perceived risk of land invasion, eviction, and encroachment.

The rationale for these three hypotheses follows. The first hypothesis attributes landscape changes to industrialization and urbanization. In this respect, forest transition theory may be critiqued as an extension of development theory. Forest transition theory treats the return of forest as a byproduct of the economic development path. It has been argued that the economic development path is most applicable to the Americas. Since it names development processes (i.e. industrialization and urbanization) as the main drivers of forest recovery, forest transition theory may be criticized for marginalizing certain local, and potentially, more direct, drivers of forest recovery in rural areas. Much like development theory, forest transition theory presents the main foci of industrialization and urbanization and marginalizes all activities, economic and otherwise, occurring in the rural sector. Development theory assumes that industrialization and urbanization are the important paradigms of economic advancement. Forest transition theory continues in this line of reasoning by assuming that industrialization and urbanization are important paradigms of environmental resource recovery.

Feminist scholars have critiqued development theory for relegating rural activities to the sidelines of economic development, and have demanded that the focus of development theory re-center or re-position the focus to the previously marginalized subjects (Peet and Hartwick 1999). In effect, forest transition theory marginalizes the shapers of the rural landscape who remain in the rural communities, after out-migration has taken place. Thus, by focusing on the processes of industrialization and urbanization, forest transition theory marginalizes those people and processes that directly make or influence land use decisions. Any theory that attempts to explain land use change as a result of people not directly affecting the landscape is troublesome. Forest transition theory may be improved by changing the foci to a new subject of inquiry: those processes occurring in and on the rural landscape.

III. Lane Tenure and Reforestation

Forest recoveries in many tropical developing countries may differ from the forest recoveries of the earlier industrializers in that people in those societies had relatively secure property rights, while many rural peoples in tropical developing countries do not. The uncertainties associated with land ownership and access rights suggest that rural peoples in tropical developing countries will experience forest resurgence in quite different ways than did rural peoples in Europe or the United States.

Neoliberal economic discourse indicates that ill-defined property rights represent major barriers to development (Sanjak, Heron, and Brown 2002; Soto 2000, 1989), and a large body of literature debates its accelerating or retarding effect on forest conservation (Berkes 2002; Fortmann and Bruce 1988). As observed, insecure land tenure constrains investment in land and deprives occupiers of formal credit, inputs and other institutional services to aid in development (Soto 1989). In this respect, the establishment (Fortmann and Bruce 1988) and enforcement of property rights has an important relationship with not only economic development and poverty alleviation (Soto 2000; Thiesenhusen 1995), but also land cover change. Insecure land tenure has frequently been described as a significant driver of deforestation in the tropics; however, secure land tenure has also been linked to significant deforestation as agro-industry represents a course of development. Thus, land tenure presents a complicated variable for consideration in forest cover change.

Land tenure, referring to the system of legal rules and local customs of ownership of land and rights to its use, is often complex in combinations of ownership and rights to use. While land tenure has been relatively more secure in earlier industrializers at the time of the observed turning points in the forest transition, secure land tenure in more developed countries is not always a given. In his 1776 *Wealth of Nations*, Adam Smith suggests that a landholder's investment in agriculture (and presumably forest-clearing that accompanies agricultural activities) increases with individual tenure security. However, the concept of tenure is elaborate in that scholars have observed that complexity, multidimensionality, and ambiguity of land tenure arrangements are more typical in the developing world than in the developed world (Ostrom 1990). In developing countries, one may observe that trees may be owned and the land is owned by another. Further complicating tenurial arrangements are that access, use-rights, and management decisions may also be nested and overlapping among different parties in managed forest and agro-forestry systems (Brondizio, Safar, and Siqueira 2002; Gammage, Benitez, and Machado 2002).

Deforestation in Europe had been promoted by the legal tradition known as assartment—appropriation of land through the clearing of trees, placing land under cultivation, and hence, securing tenure (Fortmann and Bruce 1988). Still, land tenure—even via assartment—was less complicated by the concept that land, and everything in or on it, was owned by one party outright. While assartment was more typical of frontier environments, the concept may lend itself to describe a strategy common in the tropics—that cleared land under cultivation is perceived to be owned, whether legal title is in place or not. Thus, economic development via agriculture, perception of land tenure, nested rights to access, and rates of deforestation are intimately linked.

Agricultural expansion and extensification has been identified as one of the most significant threats to tropical forests in developing countries (Geist and Lambin 2002). Large landholding commercial agriculture, held in secure tenure arrangements in Southeast Asia and the Amazon, appears to be more responsible for forest clearing today than smallholders, who dominate in Central America, with insecure property rights. Smallholders with secure property rights and access to market centers and credit may be more likely to incorporate agro-forestry and fruit farming in the diversification of agricultural activities (Rasul, Thapa, and Zoebisch 2004). Recent studies suggest that, at the regional level, secure land tenure in cooperative communities can contribute to improved forest conservation since in-migration is slowed and agricultural extensification is reduced (Carr and Barbieri 2006). Agricultural extensification is likely to be reduced since agriculture would be concentrated on the best lands for production while more marginal lands return to forest. The observation is consistent with the forest transition theory, and cooperation among multiple interests may result in a reduction of agricultural extensification more readily than in places where cooperation does not exist.

The cooperative structure of land rights may be more beneficial, then, in the particular contexts, where some rural peoples might otherwise have more limited ability to participate in secure tenure arrangements. As agriculture still represents a path for development in developing countries, one would expect that deforestation would continue where private property structures exist, cooperation is limited, and competition increases. Deforestation may, however, be slowed and forests may expand when groups with communal tenure arrangements intensify agriculture on the best lands. What this suggests is that those who are excluded from secure communal tenure arrangements would be more likely to clear forests to establish tenure security or to practice extensive forms of agriculture.

IV. Gender and Reforestation

The relationship between tenure insecurity and reforestation is complicated by gender. Blumberg's theory of gender stratification (1984) suggests that the major independent variable affecting sexual inequality is women's relative economic power. With differences in women's and men's access to and control of the means of production, including land, differences in economic power are related to differences in decision-making power regarding land use.

Gendered aspects of land tenure, potentially, have important consequences for the ecological changes taking place on the rural landscape. Yet, ‘woman’ should not be the category of analysis that challenges forest transition theory in the most effective manner. Rather, gender relations are more important for explaining differences in experiences of the rural landscape and decisions that influence the rural landscape that derive from the social constructions of gender that vary according to place.

From the top-down, macro-level patriarchal structures and institutions have real implications for women’s rights and access to land on the local level. According to Blumberg, “once societies develop complex political economies and stratification systems, extending beyond the community level, these are dominated by men,” (Blumberg 1984). Blumberg claims that inheritance and residence have significant impacts on women’s economic power. As such, patriarchal structures have direct implications for land tenure arrangements. For women, inheritance is the most direct and important means by which women attain greater economic power. However for some women, inheritance via widowhood in patriarchal societies may not result in women taking full advantage of the opportunities of greater economic power (i.e. access to credit), but rather the status quo is maintained. Marital residence patterns may influence the relative economic power of women in that the most favorable patterns are when the bride continues to reside with her female relatives after marriage and when the sexual division of labor in subsistence activities is carried out in cooperative groups. Likewise, when inheritance and marital residence patterns do not favor women, women are less likely to have relative economic power and control over decision-making with respect to land use.

Studies of deforestation have demonstrated that household composition and land title have been related to decisions to clear land (Carr 2005). Tenure insecurity, while prevalent in many developing countries, disproportionately affects women, but many studies reveal that women have significant roles in primary production in rural areas. The dynamic may not have been as relevant for the North American and European context, as most households were headed by men and tenure was relatively more secure. Even then, women's access rights may have existed through their respective role in relation to the male head of household (i.e. wife, partner, mother, sister, or daughter). This is certainly true of women in developing countries today; however, studies have shown an increase in the number of female headed households (Deere 2001). With this increase, women, in their insecure, by-association, tenure arrangement, are more likely to be landless than men.

The observation that more women are landless than men is not to replicate the recurrent binary that some men have land and most women do not (Davidson 1988), nor to universalize the Third World woman as overburdened, oppressed, illiterate, disenfranchised, poor, and voiceless (Mohanty, Russo, and Torres 1991), but rather to emphasize that institutional structures have real implications for land use decision-making with respect to gender. In addition, studies have demonstrated a land tenure-fertility relationship, in that women of households with legal title had fewer than half as many children than those from households without title in a 1990-1999 study in the forest frontier of the Ecuadorian Amazon (Carr, Pan, and Bilsborrow 2007). High fertility may actually reinforce pressures on land, and the result may have implications for forest cover change. Thus, any understanding of land tenure insecurity and reforestation in the developing world is incomplete without a reference to gender inequities.

Sometimes differences in men's and women's rights to land and to forest and agricultural products are defined by law, but more often, they are defined as a matter of marital status and marriage and inheritance laws and the enforcement of such institutions. Directly or indirectly, those laws disadvantage women more often than not; patriarchal culture and social structure can create obstacles, even when legal support exists. Even in the absence of such obstacles, standard land registration and titling, because of the complexity of tenure arrangements in the developing world, may be inappropriate (Platteau 1996).

As a result of having different jobs, responsibilities and interactions with the members of their household, community, and country (Rojas 1993), women, compared to men, possess different information about the lands they occupy and work. For instance, in his study in Senegal, William Grigsby observes "women's often disproportionate contributions [agricultural and resource production] are more remarkable given their extensive obligations to the reproduction and maintenance of the household" (Grigsby 2004). Thus, the decision to call attention to head of household gender in decisions to manage land is based in existing inequities. The combination of insecure land tenure and increase in female headed households suggests that decisions regarding land use and land cover will have very different implications for the forest transition.

Several recent studies examine gender and tenure with respect to forestry and agroforestry in developing countries, and these studies reflect the problems of a polarized structure in development policies that claimed some men had land but most women had none. There are, instead, complex and overlapping patterns of access and ownership. Dianne Rocheleau's work in Africa and the Dominican Republic has demonstrated the significance between legal and de-facto rights and legal rights versus access and control. Furthermore, gender differences may also be significant for forests in a states of contraction versus expansion (Rocheleau and Edmunds 1997).

In their analysis of the dimensions of tree tenure, Rocheleau and Edmunds find that:

> The combination of gender and resource tenure concerns has stretched the tenure question beyond two dimensional maps of land ownership to address multidimensional realities, characterized by social and ecological diversity and complex webs of connection between various groups of people and the resources that sustain them (Rocheleau and Edmunds 1997).

There are real, measurable differences in men's and women's right to own land, in men's and women's access to land and the resources there, and in men's and women's decisions to use land and resources. Relevant to forest transition theory is what gender means for forest cover change. Forest transition theory excludes and erases women and others who vary from an unstated naturalized, white, masculine norm which forest transition theory inadvertently assumes. Observed differences imply that so long as gendered tenure arrangements exist, forest cover change may also be described as gendered.

V. Migration and Reforestation

Studies of migration have proliferated over the past several decades, with particular interest in rural to urban migration and international migration (Castles and

Miller 2009). While these studies of flows of people and ideas have been critical to studies of urbanization and development, little attention has been paid to the impact of such migration on sending communities with respect to the changes to forest cover. Like most industrializing countries, recent decades have seen the dramatic increase in the number of people leaving poor rural communities in search of employment in urban centers (Castles and Miller 2009). Both young women and young men leave rural areas with roughly the same frequency. However, more middle-aged men than middle-aged women leave rural areas (Hugo 2000). This discrepancy has been well documented, but the impact of male dominated out-migration on social and political processes in the sending villages (Rudel, Bates, and Golbeck 2006) has not been evaluated as it relates to land tenure. Studies have demonstrated that gender is an important analytic category in the study of migration (Sutton 1992). Virtually no attention has been paid to the impact of male-dominated migration on decisions in sending communities to manipulate the land, and subsequently, ecological processes.

Gender differentials in out-migration have been linked, however, to impact on land cover change in the destinations. According to Barbieri and Carr, male out-migration more than female out-migration is channeled to other rural or forest areas in the case of the Amazon, since women were more likely to choose urban destinations (Barbieri and Carr 2005). In the male dominated out-migration to other rural areas, deforestation prevails. What is significant here is the implication for women. Since women are more likely to migrate to urban areas and not rural areas, women have more limited access to land and agricultural work compared to men. These gendered patterns of effects emerge in the sending communities as well. Women have more limited access to land, particularly in the developing world context. However, the absence of men may present opportunities for women in sending communities in that women have greater authority to make decisions over land use. Numerous studies have shown that women's work load may increase while resources decrease when out-migration takes away adult males. The tradeoff is that women may increase in their decision making power. However, the strains of out-migration still see exhausted soils and increased need for cash income.

Remittances are closely tied to migration and household decision making regarding land use. According to Curran and Agardy, "remittances change consumption and investment decisions with direct effects on the environment" (Curran and Agardy 2002). Remittances may act as a substitute for the rural exodus and contraction of agriculture that is predicted to take place in response to jobs in urban centers and abroad. While the rural exodus may not happen in many developing countries as it did in present-day developed countries, remittances may allow those who remain in the sending communities to refrain from participating in risky agricultural activities on marginal land. Thereby, forests may expand on these "abandoned" lands. It has been observed that outmigration and remittances have resulted in lessening pressure on some forests in developing countries (Curran and Agardy 2002). However, where tenure is insecure, the sex-selective out-migration may result in women choosing to maintain pastures on the land or others forms of extensive activities to reinforce claims to land, assuring that others see the land in productive use.

Significant and selective out-migration of men from households in rural areas will have important ramifications for the workload on women who remain. As remittances are never guaranteed, it is likely that the combination of an increase in female headed households, the increased instances of land tenure insecurity among women, and the disruptions of social relations in household and communities from the ‘missing’ cohorts will result in very different forest transitions than that of the early industrializers. With men absent from the household, women may actually have and choose to exercise greater decision-making power with respect to land use. The role of remittances and land tenure insecurity may influence those decisions by women.

Explaining the changes occurring on the rural landscape as a mere byproduct of what essentially is identified as a more important economic development occurring far removed from the site of change serves to render voiceless those processes and people in rural areas that remain after out-migration has occurred. Shaping the rural landscape is not the consequence of those who abandon it, but rather, the result of those who claim it or continue to claim it after out-migration takes place. If the theory is to be improved, it becomes critical to understand who or what claims the rural landscape and becomes the new focus of inquiry.

VI. Forest Recovery in Latin America

In recent years, scholars have begun to apply forest transition theory to Latin American societies undergoing urbanization and industrialization, such as Mexico (Klooster 2000, 2003), Ecuador (Rudel, Bates, and Machinguiashi 2002), and Puerto Rico (Rudel and Perez-Lugo 2000). The reforestation that has been observed is often patchy, with an assortment of some old-growth forests, disturbed forests with multiple users, successional forests, as well as planned orchards and living fences, interspersed with rural dwellings, agriculture, and animal husbandry activities.

Rates of recovery in these places are much slower than the rates of the earlier clearing in these places, and very often, the recovery contains significantly fewer species and at smaller range than the forest that had been cleared (Lugo and Helmer 2004). Still, the recovery represents a positive trend in forestry where successional forests, orchards and living fences contribute significantly to environmental services: carbon sequestration, soil conservation, and increase in biodiversity.

In the applications of forest transition to industrializing societies, some critical differences between contemporary industrializing countries and earlier European or North American societies have been overlooked. As Klooster (2000, 2003) has pointed out, the returning forests in industrializing countries may be vulnerable because an exodus of rural populations, as predicted with economic development, has not occurred. Where migration has occurred, men have left, and many female headed households have remained in villages where they are vulnerable to land invasions. These invasions and encroachments seem especially likely to occur given the insecure land tenure that prevails in many industrializing nations. In this context, household heads may choose to continue cultivating lands in a marginal way just to reinforce their claim to the land.

The gender-tenure insecurity dynamic currently has no place in forest transition theory. Furthermore, forest transition has been applied without consideration of the location of its application in some of the cross-national studies. Context-specific factors likely play an important role in understanding reforestation in each country and in regions within each country.

> The attention to the locality in preference to the context within which localities are shaped has thus prevented the emergence of a better understanding of how factors such as population, market demand, and state policies interact with local institutional arrangements and resource systems. (Agrawal 2002)

Latin America is frequently a site of studies on deforestation and reforestation since is it often called the “lungs of the Earth” when referring to the Amazon. However, the lungs of the Earth (i.e. Amazonian rainforests) are neighbors to some of the most heavily degraded environments in the world. Haiti and El Salvador, in particular, are among the most deforested in the Western Hemisphere.

By now examining one of the most degraded and deforested environments in Latin America, the gender-tenure insecurity dynamic may be better understood as forest recovery is now being observed in some of these places.

VII. Research Objectives

The investigation here seeks to explain how social and spatial decisions of households shape forest cover change and produce risks and benefits to households and their environments in El Salvador. Specifically, I evaluate:

(1) where and to what degree are regions experiencing reforestation;

(2) what factors, with particular emphasis on gendered migration, land tenure insecurity, perception of risks to property, and remittance incomes, influence households in household decisions about land use;

(3) how do these decisions correspond to the changes observed in land cover;

(4) in what ways do differences in forest cover change across municipalities affirm or disconfirm forest transition theory; and

(5) what are the initial benefits and/or risks to households and forests as the land reverts to forest.

The results of this research, then, are critical and timely as many parts of the tropical world are facing resurgence in forests or rather the turning point of the forest transition (Rudel 1998; Rudel et al. 2005).

Before forest transition theory becomes the basis for policy that encloses seemingly abandoned lands in the context of conservation, it is important to determine whether the theory accurately reflects the social dynamics in communities that are experiencing these changes. I hypothesize that the factors outlined above are important and must necessarily be considered in developing different strategies for protecting both forest re-growth and the poor rural peoples who may still depend on the local forests for resources. In this respect, the research reported here determines how land rights are established (Fortmann and Bruce 1988), are enforced in places experiencing out-migration, and how the confluence of factors affects forest cover in a place.

Chapter III: The Historical Context: Women, Property Rights and Reforestation in El Salvador

> Today, farmers balance a broad array of economic and social elements in the construction of livelihoods that shape the use of natural resources. Global processes (including international migration, remittances, commodity prices, international environmental ideologies) regional dynamics (such as the Central American Common Market, the Meso American Biological Corridor) national structural adjustment and development policies (like decentralization, credit, agrarian reform policies, restructured labor markets) and local socio-environmental circumstances (household strategies, tenurial structures, access rights, gender of farmers, ethnicity, traditional beliefs, natural resources endowment) all affect land use decisions in very concrete ways. Observed natural resource use reflects not just globalization "from above" but also its modification and manipulation "from below." Manifestation of these social processes includes the physical forms of the landscape, especially in resurgent forests of densely occupied rural areas and new institutional arrangements. Regenerating forests are a profound outcome of socio-economic as well as bio-geographic features. They are truly a "constructed" nature. (Hecht 2004)

Introduction

Forests are returning to El Salvador according to recent reports, and the country is experiencing an increase in wealth and rural-to-urban migration (Hecht 2004; Hecht et al. 2006; Hecht and Saatchi 2007). In a now familiar sequence of events, a forest transition appears to be underway in El Salvador. To some, this observation may come as a surprise since El Salvador is usually held as an example of extreme environmental degradation, several social and political ills, and dramatic overpopulation, characteristics that have not historically accompanied the turning point for the forest transition. Still, the observations of forest recovery seem well supported at the national level. There are, however, important empirical reasons to question whether an emerging forest transition in El Salvador takes a form similar to that experienced earlier in the now industrialized countries.

El Salvador is known as the most heavily deforested and densely populated nation in Central America. However, El Salvador's human and environmental landscape is changing rapidly with modest scholarly recognition thus far (Hecht 2004). Two of the most visible changes have been (1) the increase in international out-migration and rural-to-urban migration (Castles and Miller 2009), and (2) an increase in forest cover in rural areas (Hecht and Saatchi 2007; PRISMA 2002). While these changes are readily identifiable and may be seen across many parts of the industrializing world, the relationship between the two dynamics is less well understood (Roy Chowdhury and Schneider 2004; Lambin et al. 2001; Sader et al. 2004) and may be associated with social dynamics occurring at the community and household level, rather than with economic development per se (Stonich and DeWalt 1996).

The contextual conditions associated with the transition in El Salvador would appear to differ in important respects from the histories of landscape change in Europe and the United States. In particular, the forest transition in El Salvador differs from forest transitions in the earlier industrializers in that people in those societies had relatively more secure property rights than rural Salvadorans today (Kowalchuk 2003). The uncertainties associated with Salvadoran land tenure suggest that rural peoples will experience the forest resurgence in quite different ways than did rural peoples in Europe or the United States. These differences derive in part from tenure insecurity and the way that interacts with the increased number of female headed households (Deere 2001) in rural Salvadoran communities experiencing heavy out-migrations of males to places of work in cities and overseas (Castles and Miller 2009).

A review of the literature on rural women's experiences in Latin America suggests that rural women in El Salvador may benefit from male out-migration from rural areas to urban areas or abroad. In Costa Rica and Mexico, women have advanced their social positions in rural areas after male out-migration by receiving remittances that helps them to achieve greater economic and social well-being, by holding greater independence in decision-making within their households, by enhancing female mobility (traveling more often outside the home, within the community), and by assuming traditionally-male labor responsibilities in agriculture (feminization of agriculture) (Chant 1992; Hondagneu-Sotelo 1994). However, the reliance of women on remittance incomes can reinforce the gender imbalance and dependence on men working elsewhere and create vulnerabilities for women within the context of the community (Georges 1990).

The implications for changes in women's status as a result of male out-migration have real consequences for forest cover change, particularly if women's status is likely to change within the household and within the community (Schmook and Radel 2008; Radel and Schmook 2008). An examination of the historical conditions under which tenure insecurity and rural out-migration developed in El Salvador to the state it is in today reveal that gender underlies these processes that would influence household decisions to manage land since gendered relations can be observed within the household (i.e. the gendered division of labor and gendered decision making).

I. Land Tenure and Civil Unrest in El Salvador

In the late 1800s and early 1900s, agrarian societies in Latin America were radically altered as their agricultural goods and other primary materials were integrated into the world marketplace. Export agriculture was essential to the Salvadoran economy from the turn of the century to the early 1980s. A transformation of the economy to one dominated by agro-exports resulted in dramatic consequences for land tenure arrangements, for forest cover, and for peace in El Salvador. Today, this history has important ramifications for forest recovery in El Salvador.

During the late colonial era, in the few decades prior to independence in 1821, communal lands coexisted alongside privately-held estates or haciendas. El Salvador's system of communal lands was established by the authority of Spanish rule which designated land for a town's subsistence. These communal lands were owned by the municipality or ethnic groups and could not be sold; however, communal lands could be increased in size by purchasing additional land from the Spanish crown. Communal lands were titled and their sizes increased substantially in the areas surrounding San Salvador; while additional lands in the northeast went untitled since the ability to title new land depended heavily on the community's collective ability to raise the necessary funds. By the end of the colonial era, most agricultural productivity was centered on indigo for export. Nearly half of all production was concentrated among the poor Indian communities. These communities retained independence in access to communally held lands, and throughout the 1700s, very little competition existed for land except where dense peasant settlements coincided with the expansion of estates. More often, the communal lands were located in the interior. The hacienda economy, of about 400 large and medium-sized haciendas was limited to regions of less dense peasant settlement areas nearer to the coast and in the west. After independence, the changes to the communal landholding were gradual and significantly regionalized (Lauria-Santiago 1999).

During the colonial era, peasants were subjected to forced labor, tribute payments and other coercive practices. Upon independence in 1821, peasants were no longer subject to the taxes or forced labor practices, and between 1821 and 1870, peasants increased their access to land. The weak, new state of El Salvador did not challenge the rights of communal landholdings (Lauria-Santiago and Binford 2004). By the mid-1800s, the majority of rural Salvadorans had access to land in complex, but secure, tenure arrangements that varied tremendously in practice from one municipality to the next. As populations and competition for land for commercial agriculture increased and the power of the oligarchy government strengthened, communal landholdings came under increased government scrutiny and became the subject of increased legislation (Lauria-Santiago 1999). From 1880 to 1910, communal lands became privatized in what could be described as a move to successfully position El Salvador in the agro-export economy:

> An ill-defined and chaotic colonial pattern of land use and tenure…persuaded the coffee planters that major reforms were necessary. That these reforms led to a rapid and dramatic transformation of the entire agrarian structure may be attributed to the complete authority of a small oligarchy in whose interests the changes were made, which freed from colonial restraints, viewed the nation's land and people as resources to be used for its own benefit (Browning 1971).

Though many factors played a role in the privatization of communal lands (Lauria-Santiago 1999), the move towards large-scale, mechanized agriculture,[2] the growing

[2]The three primary cultivated crops of recent history included first coffee and then sugar and cotton. Coffee, grown ideally in the highland regions of El Salvador, was probably the least devastating of the agricultural practices, but because of its extensive cultivation and domination of the rural landscape, it still remains a concern for the sustainability of the rural environment. Sugar, grown in the central hills and upland river valleys, was grown primarily by small farmers. The crop was responsible for vast areas of deforestation. Furthermore, over-fertilization that became common by the middle of the twentieth century degraded the soil with each new season. Cotton, a strong investment during boom cycles, was the most intensive and destructive. It demanded the most inputs, and it required, like sugar, vast areas to be cleared for the production of this mono-crop. Cotton was highly vulnerable to bust cycles of the market and parasites such as whitefly that could destroy a cotton field with little warning. Cotton was grown in low-lying coastal areas, but would be replaced by cattle later. Cattle ranching turned out to be a far more lucrative investment and succeeded cotton by the early 1960s. Cattle ranching practices were equally devastating for the environment. While the coffee boom of the late 1800s had perhaps the most acute

influence of the landowning elite and an emerging middle class were perhaps most important in the support for privatization. The state abolished communal forms of tenure in the early 1880s when at the time over 40% of all land in El Salvador was held by traditional campesino communities (Bremond 2007). Peasants were given the opportunity to make claims to plots within communal land; however, the administration of communal lands and those who were using them varied tremendously within each community, where in some cases, a class structure had evolved within the communal lands, and in other cases, title had not been established to the communal lands (i.e. in the northeast). The result was that many peasants were unable to formally make claims or to receive recognition of ownership to individual plots.

Following the abolition of communal land tenure, peasants who had not or could not legally established claims to community lands became tenants, squatters, or laborers and became dependent on the landowning elite. Landowning patrons and their tenants were often engaged in agreements that made the campesino disproportionately and heavily dependent upon the patron. When patrons insured campesinos against risks in agriculture, campesinos were better protected against the losses of failed crops; however, they were often more vulnerable in agreements that were severely unequal in terms of exchange.[3] Because the patron was less dependent on the individual campesino than vice versa, a national economic shift to agro-exports in the late nineteenth century provided incentive to patrons to change the patron-campesino arrangements in a way that made

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consequences for land tenure, land use patterns, and social equality in El Salvador, the overall transition to agro-exports lent permanence to the changing nature of land ownership and simultaneously to forests in El Salvador.

[3] See Scott, J. C. 1977. The moral economy of the peasant: rebellion and subsistence in Southeast Asia. New Haven: Yale University Press.

campesinos increasingly vulnerable but provided an opportunity for the patron to rid himself of the dispensable campesino after the tenant failed to meet the terms of agreements (Mason 1998). The period from 1912 to 1932 was known as the Golden Age of the Salvadoran bourgeoisie (Beverley 1982). Patrons actively sought ways to convert haciendas to large-scale, mechanized farms employing seasonal wage laborers. In order to accomplish the transition, patrons no longer needed a year-round, resident worker population, but instead needed the lands under subsistence cultivation to add to production in cash crops. Campesinos were displaced and became landless, civil unrest resulted, and a military government enforced policies to enhance the agro-exports and suppress campesino uprisings.[4]

Patrons changed the structure of the relationship with the campesinos or tenants from one that resembled sharecropping to one that demanded tenants make cash payments for rent of land at the beginning of the growing season. The shift was to, in effect, indirectly evict tenants who now assumed the risk of crops, faced few choices but to participate in cash cropping and abandon subsistence cultivation, and struggled to meet the cash demands of purchasing subsistence goods (Williams 1986). Increasingly patrons hired seasonal temporary labor since mechanization reduced the demand for permanent, year-long labor. The temporary labor was hired at lower wages as the demand for labor diminished and the supply of labor increased as greater numbers of campesinos became landless. As they struggled to meet their financial obligations with the patron and as they competed with the cheaper hired labor, the tenants were unsuccessful in meeting the new terms of trade and rent with the patron and their numbers decreased by as much as 70%

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[4] Most notably was the 1932 peasant uprising in the western departments of El Salvador after coffee prices dropped, haciendas closed, and mass unemployment led to a deep economic crisis.

by the end of World War II (Williams 1986). Moreover, the success in cotton and cattle increasingly reduced the demand for labor and with population growth greater than 3% annually, the pressures on labor market and wages continued unabated through the 1970s (Seligson 1995). Responses to such pressures would naturally result in increases in migration, both international and rural-to-urban. Though the flows to industrial jobs in San Salvador could not absorb the vast numbers of landless campesinos, and those previously engaged in subsistence agriculture now found themselves dependent on a market to purchase subsistence goods (Mason 1998).

The agro-export economy in El Salvador served to dramatically increase the landlessness of campesinos, the profits of landed elite, and the rate of deforestation; however, the reliance on only a few cash-crops created even greater pressure on an already strained economy with so many unemployed or underemployed. In an attempt to combat the extreme volatility of coffee prices in El Salvador, promotions of other non-traditional export crops were tried to ease the threat of revolution and nationalization of U.S. economic interests. A diversification of exports improved conditions in El Salvador and strengthened investment opportunities for Americans abroad (Williams 1986). Aggressive efforts to increase agro-export production on lands not already utilized or underutilized and the increasing subsistence production by ousted campesinos on more marginal lands increased pressure on an already fragile environment. Forests, by now, were decimated on the rural landscape, though El Salvador had historically seen high rates of deforestation since Pre-Columbian times (Dull 2007). When recession struck in the 1970s, much of Central America was faced with economic disaster as demand for many of their products was abruptly halted.

> In a system dominated by land owning elites with international ties, land tenure was by the late 1970s severely unequal and unemployment was greater than 50%. The shift to export agriculture left El Salvador with one of the most inequitable land tenure systems in all of Latin America. By 1971, estates larger than 200 hectares constituted only 1.5% of farms but controlled 49.5% of all farmland, while farms of fewer than 10 hectares accounted for 92.7% of all farms but little more than a quarter of all farmland. (Mason 1998)

This extreme polarization, where by 1980 landlessness had reached 65% of all rural households (Williams 1986), may be viewed as an accelerant for the civil conflict that erupted during the 1980s (Paige 1997). However even if land reform had resulted in equal distribution, some Salvadoran agriculturalists still would have been landless or land poor. That is not to say that land reform was not an important part of peace and increasing equality in El Salvador, but rather it is to emphasize that land reform would never cure the overwhelming land shortage problems for the Salvadoran campesinos. Today, income continues to be highly concentrated among the few, and despite agrarian reforms that resulted in a significant portion of El Salvador's land being redistributed, low wages, high unemployment and landlessness continues as a major source of poverty in El Salvador. To understand this trend, an examination of El Salvador's land reform during the civil war reveals some problems.

By 1979, the crisis of political turmoil, economic decline, poverty and inequality had reached a boiling point in El Salvador. The subsequent civil war that lasted from 1979 to 1992 was highly regionalized in its impacts on some parts of the parts versus others. Widespread political mobilization in both urban and rural El Salvador was met with brutal responses by military forces that later deepened into full civil war. Up to one million persons were displaced between 1979 and 1982. By the conclusion of the conflict in 1992, up to one million additional persons were displaced (Lauria-Santiago and

Binford 2004). Through the war, however, land reform programs were underway that resulted in a complicated system of tenure arrangements that today are burdened by insecurity and uncertainty.

A three-phase land reform introduced at the start of the civil war was to provide 100,000 to 200,000 households with land in private or cooperative holdings. Phase I was responsible for the elimination of large estates in holdings larger than 500 hectares. The large estates were converted into cooperatives owned collectively by resident workers who actively worked the fields away from the households. Incidentally, men were overwhelming more likely to be granted rights in the cooperative over women. According to reports, 469 estates over more than 215,000 hectares became 317 cooperatives. Prior to the implementation of Phase I, these areas comprised 14% of all of El Salvador's coffee production, 23% of cotton, and 35% of sugar (Thiesenhusen 1995). The next stage of the land reform, Phase II, targeted the next largest set of estates in the country, those with areas between 100 to 500 hectares, and those significantly under cash crop cultivation. However, the landed elites responded to the threat of impending expropriation in Phase II by exerting political influence that granted large-holders three years to subdivide, sell or transfer land in order to reduce holdings in a way (i.e. transfer to friends and relatives) that they would not subject them to the dramatic expropriation under the reform (Kowalchuk 2003).

With the failure of Phase II, the third and final stage of the reform, Phase III was implemented in a land-to-the-tiller program. Those renting farmland, very little of which was cultivated for cash crops, of less than 7 hectares were granted the ownership rights to that land. Approximately 130,000 families were affected by the implementation of Phase

III. However, the reforms were unequal in their impact on men and women, since women were more likely to be the landholder renting plots out to "tillers" who were more often men, women disproportionately lost ownership over lands. The land reforms also neglected to make any concessions for the already landless masses. Because Phase I affected only those resident workers still on their patron's estates (a number that was reduced by nearly 70% over the previous decades) and Phase III affected only those renting on smallholdings, the landless received no benefit from the reform (Mason 1998). In addition, many smallholders eligible under Phase III were evicted or were threatened before they were able to file legal claim to their plots. The process of registering land, today, includes a five step registration process which takes on average, five days, and costs up to US$7,805 (Cahill 2006).

By the end of the war in 1992, when the Peace Accords were signed, 200,000 people had died, and 2,000,000 people had migrated out of the country. The Peace Accords would include agreements over land reform, decentralization, and democracy. In the Programa de Tranferencia de Tierras (PTT), approximately 10% of the country's agricultural land was further transferred to ex-combatants of both sides of the conflict (Bremond 2007). The properties transferred included those owned by the state, those that exceeded a constitutional limit of 245 hectares, and private properties that were voluntarily offered up for sale. Thus, there have been marked successes with land reforms in El Salvador, but since no agricultural census has been completed since 1971, it is difficult to access the measurable impacts aside from the reported figures of size of lands and ownership structure (Seligson 1995).

Another assumption made by the land reform and land reform proponents (Soto 2000) is that private property structures that have historically worked reasonably well in the North and so they should do the same in the South. However, they may not deliver justice and economic gain when applied there. The success of the agrarian reform has been considered, by most, unsuccessful or at the very least plagued with inefficiencies. Seligson, in his analysis of the outcomes of land reform in El Salvador, concludes:

> …although the war, land reform, urban and international migration, and declines in the birthrate have combined to diminish the agrarian question and its importance in the national scheme of things, the problem of access to land has not been solved for hundreds of thousands of Salvadorans. The unavailability of sufficient land will prevent most of them from acquiring land and this condemns them to absolute poverty and relative deprivation….Second, the peace accords gave highest priority for land claims to those who fought for the government or the army. The landless, land-poor, and unemployed who stayed on the sidelines during the war and did not engage in combat…got nothing…it may be that as peace comes to El Salvador, the legacy of human suffering caused by land scarcity and overpopulation will remain an enduring feature of the landscape for decades to come (Seligson 1995).

With claims of land scarcity and overpopulation, it becomes difficult to validate the claims that forest recovery is being observed in El Salvador, since forest recovery suggests abandonment of agricultural lands. A more careful analysis of women's legal right to own, access, or manage land in El Salvador reveals some important trends.

II. Women in Rural El Salvador

Despite reform and advances by the Peace Accords of 1992, property rights are structured in El Salvador in such a way that gender is addressed in the language of the civil code, intended to protect women's rights to own property. However, failures to recognize differences in enforcement of stated rights, cultural practice, and implications for other national polices may inadvertently lead to discrimination against women with regard to land tenure. As such, agrarian reform has resulted in gender biases in land redistribution. Agrarian reform that benefited only male household heads is problematic since rural women's participation in agriculture appears to be greatest among the peasantry, smallholders, and near landless (Deere and Leon 1987; Deere 2001). In this manner, gender relations in the property rights regime are deeply embedded in Salvadoran society via the direct and indirect actions of the state. Differences in gendered land tenure regimes in El Salvador may have consequences for local land use decision making and forest cover change.

Agrarian reform has been negligible in increasing land ownership among women in rural El Salvador. Even though agrarian reform was intended to create a more equally distributed land tenure system, women were inadvertently excluded. Because agrarian reform was first aimed, in Phase I, at creating cooperatives from the largest estates that would serve to provide permanent land access to resident workers, more often men were the beneficiaries. Since men were primarily working in the fields prior to the reform, men more often became the members of the cooperatives after the reform that granted rights to those who worked in the field (dominated by men). Little changed in the day to day activities after estates became cooperatives; however, the value of many cooperatives declined as large landholders de-capitalized their estates prior to the transfer of ownership to the cooperative. In Phase III, women may have actually been made worse off by the terms of the reform. Since women were more likely to rent land to tenants in old age (after inheriting land) and Phase III provided land to those who were actively working it (more often men), women were negatively affected at a higher rate than were men (Deere

2001). Finally, PTT provided greater provision for ex-combatants, who were more often men than women.

According to the Civil Code of Salvadoran law, Article 182 states that a husband owes protection to his wife, and a wife owes obedience to her husband. In addition, Article 183 states that the husband may demand that his wife live with him and join him in wherever residence he chooses to establish. If his wife refuses to follow her husband, her husband has the right to refuse support to wife (Pinzon 1994). The context of the law and practice in society illustrates the dependent position that women face within the household.

While the articles are among the few legal clauses that indicate a form of inequality between men and women, many other legal institutions exist that demonstrate that women are permitted equal rights to property as a matter of law. Since it has been demonstrated that most women come to own land in El Salvador via inheritance and women have the same inheritance rights as men in law, marital regimes are an important aspect of Salvadoran law to consider.

Civil code provides that couples select, at the time of marriage, how assets will be divided in case of the dissolution of the marriage or death. El Salvador, compared to many other Latin American countries, is considered significantly more progressive in this respect. Couples have the choice of three property regimes at the time of marriage: full common property, participation in profits, and separation of property. Full common property is the default option, when no selection is made at the time of marriage. El Salvador is considered to offer the most favorable conditions for women and rights to property of any country in Latin America, since common property exists as the default only in El Salvador. However, empirical evidence suggests that these regimes are invoked with limited frequency as the separation of property is most common in practice. As this discrepancy suggests, the participation of women in the decision-making process for marital regime selection is less well understood (Deere 2001).

Full common property is characterized as the pooling of all property and assets that were introduced to the marriage and acquired during the marriage. At the end of the marriage, all assets are divided in half. The regime of participation in profits recognizes that all property and assets introduced at the time of the marriage and acquired during the marriage, individually, will be retained by the individuals at the dissolution of the marriage or at the time of death. In addition, any profits derived from the individual assets, regardless of initial ownership, are pooled in common and divided equally. Under the separation of property regime, there is no pooling or division of property. All assets and property are maintained by the individuals separately regardless of the time of acquisition. Separation of property is more likely to exclude women from acquiring rights to land, if one is to assume that the agrarian reform benefited men more often than it benefited women.

Consensual unions are recognized in El Salvador, and couples living in a common law marriage may exercise the same rights as married couples with respect to division of property and assets at the dissolution of the relationship; however, since no official union takes place, assets and property are divided according to the common property regime, the default. Since consensual unions are extremely common in the rural areas, accounting for more than half of all unions there (Pinzon 1994), consensual unions potentially are at greater risk of non-enforcement of the common property regime at the dissolution of the union.

Not until 1993 did El Salvador civil code recognize consensual unions, and thus, under agrarian reform, many women in rural El Salvador may have been excluded from the benefits of land reform programs under Phase I, Phase III, or PTT. In response to the apparent discrimination, the state made allowances for full common property division of assets to be recognized; however, the state required that the union be proved and then recognized officially by a notary or judge. The couple must demonstrate evidence of (1) cohabitation for at least three years, (2) children, and (3) no previous marriage (Deere 2001). The change in law allows for additional protections, but many unions are never formalized. The result is that a companion in an unrecognized consensual union may be disinherited. In rural areas, women face vulnerability disproportionately in their ability to assert their rights over assets since they are less likely than women in urban settings to have their unions recognized in any legal manner.

Common property marriage, theoretically, should allow for the increase in women's access to legal claim to land. In practice however, the high rate of consensual unions in rural areas, the financial constraints to having a union recognized, the financial constraints of filing claim to land, and the observations of cultural practice that men are recognized as the producers of land (and therefore, the rightful owners of that land) and women work in support of that production all represent challenges to women in establishing legal ownership to land. In practice, priority is generally given to men in acquiring land, inputs, and credit. Nearly all legal statutes do not discriminate in language that establishes rules of obtaining credit; however, higher rates of illiteracy among women and the prevailing belief that women work alongside their partners in agriculture but not as producers in their own right are significant social obstacles in efforts to take advantage of the legal framework.

In 2007, 34 percent of Salvadoran families nationwide were headed by women (CEDAW 2007). The trend is a result of male-dominated migration since the start of the civil war. The male-dominated migration, particularly from rural areas, has created a rural landscape increasingly occupied by women and children remaining in poverty and relying on remittances from incomes originating from a population of over one million now living abroad in the United States, Costa Rica, Honduras, and Mexico and from those workers who spend a majority of their work week in San Salvador. Almost one-sixth of Salvadoran nationals are not living in El Salvador most of the time (Bailey et al. 2002). In some cases, Salvadorans living abroad send remittances back to sending households (see Table 3.1).

Table 3.1. Remittances by household in El Salvador.

Department by Zone	Households with at least one member out-migrated	Households with out-migration as a total percentage of the country	Households Receiving Cash Remittances	Households Receiving In-Kind Remittances	Households Receiving Both Cash and In-Kind Remittances	Total Households Receiving Remittances	Percentage of Households Receiving Remittances	Total Households Not Receiving Remittances
Occidental								
Ahuachapan	7880	12.4	6273	436	2161	8870	13.9	54637
Santa Ana	20779	17.0	19385	1479	6298	27162	22.2	95043
Sonsonate	10220	11.9	8316	372	3016	11704	12.5	81876
Central								
Chalatenango	8141	20.0	6119	503	3042	9664	23.7	31139
La Libertad	18411	12.5	16148	1032	4760	21940	14.9	125704
San Salvador	64761	13.8	53547	4598	17841	75986	16.2	393261
Cuscatlan	5652	13.6	4895	301	1782	6978	16.8	34618
Para-central								
La Paz	8983	14.9	8232	540	2819	11591	19.3	46577
Cabanas	6840	23.9	6080	215	1750	8045	28.1	20535
San Vicente	5102	15.4	3596	118	1712	5426	16.4	27750
Oriental								
Usulutan	14154	18.9	11350	837	4600	16787	22.4	58217
San Miguel	24336	22.1	21171	350	8138	29659	27.2	80386
Morazan	10332	28.2	9282	132	2644	12058	32.9	24589
La Union	18121	29.8	16966	678	5296	22940	37.7	37833

Source: Direccion General de Estadistica y Censos, 1999

Remittance monies have freed many households from cultivating the land to meet subsistence needs, but this freedom has brought with it new risks, in particular the risk of land invasions and encroachment on to lands that are held informally (Soto 2000). With men absent from the household and community, female-headed households in some instances become more vulnerable to intimidation and encroachment on their lands. Their vulnerability may be particularly acute, if their lands are at least in some places reverting to forest, and therefore, appearing to be 'unused,' or otherwise, not cultivated in traditional agricultural production (Hamilton and Fischer 2003), but female-headed households are particularly dependent, as observed in some parts of El Salvador (Gammage, Benitez, and Machado 2002). These problems may be compounded by the prior difficulties that women experience in acquiring land with secure property rights (Agrawal 2002). Surveys of women's perceptions of the justice systems' ability to enforce law in the interest of women reveal that gender-neutral laws may not be gender-neutral after all since other domains (i.e. economic institutions) are gendered (Walker 2008a).

III. Forests in Rural El Salvador: What is Forest?

While some report recovery in El Salvador's forests (Hecht and Saatchi 2007), others point to contraction (Coffee forests shrink in El Salvador 2006). Some studies of deforestation in El Salvador have clearly described the destruction of old-growth forest ecosystems. Factors that have contributed to the destruction of mangrove forests in El Salvador has been linked to a system of confusing, complex and at times contradictory laws and regulations that govern access to and use of forest resources (Gammage, Benitez, and Machado 2002). Reasons for deforestation have been related to agricultural conversion, including cattle ranching, in some regions of El Salvador, relocation and resettlement of communities displaced by war, and commercial and individual extraction for timber and fuel wood. According to PROCAFE (El Salvador's Foundation for Coffee Research), El Salvador lost 21,025 hectares of forest-covered coffee farms between 2001 and 2004. The contraction of forest was explained by urban expansion, lack of investment in coffee farms, farmer indebtedness, migration, and weak regulation regarding land use change (Coffee forests shrink in El Salvador 2006). These seemingly conflicting reports leads one to question what exactly is considered forest.

In their observations of forest resurgence in El Salvador, Hecht and Saatchi claim that secondary growth and advanced pasture successions represent the largest forest types. Based on archaeological observations that El Salvador has faced severe deforestation pressures since Pre-Columbian times, it seems likely that much of El Salvador's forest can be characterized as secondary (Dull 2007). Despite its reputation of being severely deforested, Hecht estimates that the country has at least 600,000-700,000 ha of tree cover of all types or at least a third of the country is forested (Hecht 2004).

Forests, however, may also be defined as encompassing the human activities that incorporate a variety of land uses. Planned biodiversity may include components of agro-forestry with direct implications for forest cover change. Shade coffee systems have potential for contributing to tropical forest biodiversity (Perfecto, Greenberg, and Voort 1996). Moreover, living fences, gardens, orchards, and scrub growth all have important ramifications for the transition to increasing forest cover. Traditionally, these forest types may have been ignored or excluded from discussions about forest conservation, and for advocates of protecting old-growth forests from destruction, these pseudo-forests offer very little in terms of offering an alternative. However, to ignore them entirely would be to miss an important opportunity to understand shifts from extensive forms of agriculture to more efficient and diverse forms of agriculture and land use that may have important ramifications for forest conservation. As it increasingly seems to be the case, forest recovery in the tropics are constructed in nature by the gendered household heads, the gendered migration patterns, and the gendered decisions to manage land.

IV. Scenarios for Forest Cover Change

There are several possible scenarios that may result from the human-ecological dynamics that occur in rural El Salvador. In the first scenario, remittances would allow rural Salvadorans to refrain from cultivating the land, and forests would return spontaneously. This scenario is consistent with the predictions of the forest transition theory because income from a new non-farming source reduces human pressure on the land. Remittances, in essence, act as a substitute for rural out-migration, and this pattern would then be consistent with the economic development path.

In the second scenario, remittances would allow rural Salvadorans to refrain from cultivating the land, but forests do not return as expected in forest transition theory. This scenario requires investigation into the possible factors that motivate continued land clearing, e.g. perceived threats to land tenure, agricultural extensification.

In the third scenario, male out-migration does not occur to the same extent, but forests return nevertheless. Potentially, the scenario presents itself as the case of the forest scarcity path. However, scholars have recognized that the forest scarcity path is most often observed outside of Latin America. This scenario, seemly inconsistent with forest transition theory, also requires investigation into the possible additional factors that allow rural Salvadorans to refrain from cultivating the land (Hamilton and Fischer 2003),

To examine the human dimensions of forest cover change in El Salvador, I assess forest cover change in El Salvador via remote sensing analysis of Ahuachapán, El Salvador (see chapter 4) to affirm the observations of increasing forest cover in El Salvador. Once the turning point in the forest transition has been established, I link forest cover change at the national scale to social variables that incorporate gender to explore the possibility of gendered land-use decisions on forest cover change (see chapter 5). Finally, gendered, local scale decision-making is further explored in the context of a case study of Cantón El Tigre, El Salvador (see chapter 6).

Chapter IV: Forest Cover Change Detection in Ahuachapán, Ahuachapán, El Salvador

Introduction

In the tropics, forest cover is changing rapidly, and physical and social scientists are interested in assessing those changes with a high degree of precision. Accurate measures of forest cover change have become increasingly important as quantification of carbon storage is critical in climate change scenario modeling and planning (Andersson, Evans, and Richards 2009; Lambin, Geist, and Lepers 2003). As major land use transitions are primarily occurring in the tropics (DeFries, Asner, and Foley 2006), those same time-series measures may be used to understand a country's or a region's position along the forest transition.

Scholars have increasingly turned to remotely sensed data analysis with the objective of quantifying and describing surface patterns. The expectation is that forest cover information may be derived more quickly and more cost effectively than the time and expense required to complete labor-intensive, ground-based surveys or in situ data collection over several weeks, months, or even years (Foody 2003). Moreover, detecting change via remotely sensed data holds the promise of eliminating inconsistencies among data collected by multiple surveyors across multiple dates.

Since forest transition theory describes net forest cover change at the national level, remotely sensed data would potentially assist scholars in assessing a country's transition by capturing forest cover for the entire area of the country in a time-series. Regional patterns of reforestation, derived via remote sensing analysis, in rural El Salvador (Hecht and Saatchi 2007) and case studies of increasing forest cover (see chapter 6) are strong evidence that El Salvador may be experiencing the turning point in forest transition. However, interpretation of digital images *or* of ground surveys may be insufficient to make assessments about a forest transition in El Salvador when considered alone. In this chapter, I employ common and emerging methods used in detecting forest cover change, and then I reflect upon the relationship between the use of remote sensing analysis and land transitions.

I. Considerations for Measuring Forest Cover Change

Despite the promises of remote sensing and tremendous advances in the technology and interpretation (Rogan and Chen 2003), measuring forest cover via remotely sensed data has proven difficult. Remote sensing analysis of forests requires the accurate interpretation of reflected electromagnetic energy from the earth's surface. Since forest cover conditions are constantly changing, the reflectance also changes. Forests experience natural fluctuations in reflectance from seasonal changes, exposure to stresses (i.e. disease or drought), and changes in biomass accumulation as forests mature or as forests are selectively cut (Knipling 1970); definitions of what constitutes "forest" are not absolute (Kleinn 2001); and the quality of forests are not considered. Each of these changing conditions has a particular set of consequences for how conversions from forest to non-forest or from non-forest to forest are then quantified.

Observation and estimation of forest cover are usually based upon a definition of forest and of sample size. Historically, forest was only defined as areas outside of permanent settlements. Forest definitions increasing are methodologically driven, but the lack of a generally acknowledged forest definition too often means that forest cover estimates are not comparable across studies where different definitions have been utilized. Percentage of minimum crown cover is often part or the whole of how forest is defined, and in general, it is characterized by high density tree species of closed canopy. The FAO (Forest resource assessment 2000 - terms and definitions 1998) defines forest as minimum crown cover of 10% and a minimum area of 0.5 ha. Trees are defined as plants reaching heights greater than 2 – 5 m. The size of the sampling unit, or spatial resolution, has been demonstrated to have an effect on the total cover estimates, and the effect is particularly consequential when forests are fragmented (Kleinn 2001). When high-resolution images are degraded to low-resolution images by combining data in the collapsed pixels, there are changes in the estimates of percentages of forest cover (Woodcock and Strahler 1987). Where forest is fragmented, as is typically the case in areas of forest recovery in El Salvador, the definition of forest and the sample area size are particularly relevant.

Per the United Nations Framework Convention on Climate Change (UNFCCC), *regular* monitoring of changes in forest versus non-forest vegetative cover is required to accurately quantify the forest biomass. Scientists are interpreting remotely sensed imagery to examine forest cover, patterns of deforestation and reforestation, and characteristics of forests. The choice in the remotely sensed data set employed in a study will often result in variations in estimates of forest cover and forest change. Since cost is often factored into the rationale for opting to use remotely sensed data in forest cover change analysis, it is important to note that costs vary widely depending on the choices of the analyst. Aside from cost considerations, spatial and temporal resolutions are considered of high importance. Remotely sensed data sets (i.e. Landsat TM, ETM+, MSS, SPOT, ASTER) of fine spatial resolution[5] (10-100m) are considered well suited for land classification. Remotely sensed data sets (i.e. MODIS) of coarse spatial resolution (>100 m) and of relatively low cost are appropriate for measuring the spatial extent of forests, but they not very appropriate for land classification. Remotely sensed data sets (i.e. IKONOS, Quickbird) of ultra-fine resolution (<5m) are often the most expensive, but valuable in measuring canopy cover. The data sets vary in temporal resolution or how often the sensor records imagery for a given area. High temporal resolution (i.e. hourly) is not as critical for measuring forest cover change; but, the sensor must obtain data repetitively for accurate assessments of forest cover and change. High radiometric resolution[6] increases the probability that an earth surface process will be captured more accurately, but high radiometric resolution and high spatial resolution is often had at a much higher cost. Finally, analysts choose among data sets for differences in spectral resolution (or the specific wavelength intervals in the electromagnetic spectrum to which the sensor detects). Careful selection of the spectral resolution is likely to improve the likelihood of accurate assessments of forest cover and change.

While complete coverage using Landsat Thematic Mapper (Landsat TM and ETM+) data is preferred among analysts for land classification and change detection, many countries are constrained by the cost of the data. UNFCCC has suggested sampling using a hierarchical and nested approach by examining medium to coarse resolution imagery (DeFries et al. 2002) to first identify areas of rapid land cover change and then interpret higher resolution imagery in the identified areas for more accurate accounting. The method is likely beneficial in areas where large-scale deforestation is taking place or

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[5] While analysts do not agree on categories of spatial resolution, fine spatial resolution generally refers to the pixel size or nominal spatial resolution or 10 x 10m to 100 x 100m.

[6] Radiometric resolution refers to the signal strength as the sensor records radiant flux.

in areas where large-scale replanting efforts are underway. The technique likely presents challenges where secondary forests are just now emerging and are not easily detected using coarse resolution or where fragmentation is high and not easily detected with coarser spatial resolution data since pixels may be "mixed" (i.e. incorporating the spectral signatures of several land cover types. Spectral un-mixing techniques may be appropriate for transitions that are at some of the earliest stages. Critical reforestation, and a forest transition, may go undetected otherwise.

While remotely sensed data collection may overcome some of the limitations of in situ data collection, the interpretation of remotely sensed data may be improved by direct observations from the field. Remotely sensed data captures only land cover type, not the processes or phenomena that influences land cover. For this reason, many social scientists have not incorporated remote sensing analysis into their research (Rindfuss and Stern 1998). Scholars interested in the forest transition are often more interested in the social drivers of that transition and are not particularly concerned with the biophysical aspects of the forest recovery. Remotely sensed estimates of forest cover change reflect land cover only, not land use. The terms are significant in that land cover is meant to reflect only those biophysical conditions of the landscape, not the social and economic aspects for which land use is the more appropriate terminology. Land cover change, then, describes only the conversion from one class of land cover to another through conversion, and it may not describe the thinning of forest, for example, nor the change in designated use or value to humans (i.e. conversion of old-growth to agro-forestry operations with significantly less biodiversity in most cases).

Remote sensing analysis alone does not rank a forest's importance or for the prediction of its continued existence since land use is not accounted for. Some forests *are* more important than others as it relates to carbon storage (i.e. old growth is more important than secondary growth and both are more important than scrub growth). Still, some forests (i.e. living fences as 'linear' forests, orchards as agro-forests) may be inadvertently or intentionally unaccounted for in climate storage assessments. However, agro-forestry, living fences, and other early secondary growth may be important in understanding the stage of the forest transition, particularly in the El Salvador case where less than 3% of all forest is old-growth forest. Since secondary growth and agro-forests in the tropical setting are difficult to detect using remote sensing alone, methods should be improved upon to ensure that these forest covers are counted. The marriage of remotely sensed data and ground-truthed data or direct observation of changes in land cover helps researchers to link land cover to land use and subsequently to land transitions.

With recent evidence indicating that El Salvador is experiencing a forest transition or that globalization is having a positive effect on forest re-growth (Hecht and Saatchi 2007), remote sensing technology helps to overcome the limits of ground-based monitoring methods. Regular monitoring of forest cover change becomes a necessary predecessor to making the claim that El Salvador is or is not experiencing forest recovery in a forest transition, but given the history of extensive deforestation in the country, it is unlikely that remote sensing alone can determine the full extent of forest cover change. Forest recovery, if any, would likely be fragmented, and population in rural areas is still high. Thus, remote sensing analysis coupled with ground-based assessments may provide a better assessment of El Salvador's land transition than remote sensing analysis alone.

The challenge is how to best detect the changes in a tropical setting using remote sensing when so many options exist for the analyst.

In addition to the many choices in data sets, many more methods are in use for interpreting the remotely sensed data. Three methods are explored for their potential value in discriminating forest from non-forest, where forest includes secondary forests, orchards, and living fences. These methods include NDVI, NDMI, and cluster analysis. The issues surrounding their utilization are discussed in the methods section.

II. Hypothesis

Biophysical conditions, population density, migration, remittances, social capital, perceptions of forest benefits, land tenure, and household composition all interact to influence land transitions (see chapter 6). In the rural areas of the municipality of Ahuachapán, El Salvador, population pressures are still high. Subsistence agriculture and some cash cropping prevail. Out-migration levels are low and remittances are at best minimal and unreliable for those families with family members who have left. In addition, forest recovery has been reported (Hecht and Saatchi 2007). Given these conditions, the municipality represents somewhat of an anomaly in forest transition theory. It is unclear whether forests can recover under these conditions. Using the municipality of Ahuachapán, El Salvador as a sample, I test the hypothesis that forest recovery is occurring in El Salvador.

III. Methodology

Study Area and Background

The municipality of Ahuachapán in the department of Ahuachapán, El Salvador was selected for its proximate location to several protected areas in El Salvador and because parts of the municipality contain proposed and existing protected areas of the MesoAmerican Biological Corridor. Spanning approximately 282 km^2 in western El Salvador (see Figure 4.1), the municipality was identified as having experienced significant forest recovery in recent years (Hecht and Saatchi 2007). Using coarse resolution imagery (MODIS), Ahuachapán has netted a 24.87 sq. km. gain in forest cover (see chapter 5) between 2000 and 2005; however, the estimate only assesses spatial extent. Ahuachapán is representative of the types of land covers that are typical for several parts of El Salvador that have gained attention recently for forest recovery. Prominent land covers include secondary forests, shade coffee (Mendez, Gliessman, and Gilbert 2007), orchards, living fences, and agriculture. The population density in the municipality is 349 persons/sq. km., average for the country.

Forests in El Salvador have a long-standing history of human intervention and management. Dating back as early as 4000 years ago, pressures on forest resources have resulted in a series of dramatic forest cover losses over the preceding four millennia (Dull 2007). As such, prior to the colonial era, the anthropogenic landscape had already been transformed by high population densities and sedentary agriculture (Denevan 1992), and continuous forest cover was not present across the country (Dull 2007). Savannah and scrub-like forests prevailed throughout much of El Salvador’s history, though denser forest cover increased during warmer periods. Scholars have suggested that the intensification of commercial agriculture by the mid 1800s was not the driving force behind deforestation and soil erosion and degradation in El Salvador, though commercial agriculture exacerbated an already declining and deforested landscape (Dull 2007). Thus, in many ways, one may question what the landscape would revert to, if left abandoned. Forest transition assumes that the natural state is a forested one.

Data Sources

One orthorectified Landsat Thematic Mapper (TM) image for April 7, 1986 from the Global Land Cover Facility, University of Maryland[7] and one Landsat Enhanced Thematic Mapper Plus (ETM+) image for April 14, 2003 from the United States Geological Survey were acquired. The images capture the northwest portion of El Salvador, and the study area of the municipality of Ahuachapán (World Wide Reference System path 19, row 50) (see Figure 4.1). Aerial photographs for the study area in 2005 were acquired from El Salvador's National Registry. Longtime residents of the study area served as informants on past and present land cover and land use. In addition, existing land cover classification maps were acquired from El Salvador's National Registry, El Salvador's Ministry for the Environment and Natural Resources (MARN), and non-governmental organizations to aid in the interpretation of land cover and assessment of results accuracy.

Seasonal changes potentially impact land cover classifications. In El Salvador, a tropical climate prevails with little seasonal difference in temperature. Forest types are consistent with the tropical dry broadleaf forest biome or tropical dry forest biome where the climate is warm year-round with approximately 200-cm of precipitation annually.

[7] http://glcfapp.umiacs.umd.edu

However, seasonal differences in precipitation result in distinct wet (May-October) and dry (November-April) periods. In addition, El Salvador is subject to the effects of the El Nino-Southern Oscillation.[8] Deciduous trees are prevalent in El Salvador's dry tropical forests, and as such, forests may appear leafless during the driest conditions. However, evergreen trees are also an important component of El Salvador's forest ecosystems. The last of El Salvador's Central American pine-oak forests are found in western El Salvador in El Imposible National Park and Montecristo National Park.[9]

To reduce scene-to-scene variation due to sun angle, soil moisture, atmospheric conditions, cloud cover, and vegetation phenology differences across seasons, data were collected for the month of April, corresponding to El Salvador's dry season. In selecting near-anniversary dates, it becomes possible to avoid detecting changes in forest cover that may be seasonal in nature only and not of interest here.

[8] 1985-1986 was not an El Nino year; however, 2002-2003 was reported as an El Nino year. The implication is that conditions in 2002-2003 are abnormally drier conditions. Forest cover change analysis may be affected by these conditions.
[9] See Instituto Geográfico Nacional "Ingeniero Pablo Arnoldo Guzmán". 1987. Mapas básicos de la República de El Salvador. San Salvador, El Salvador.

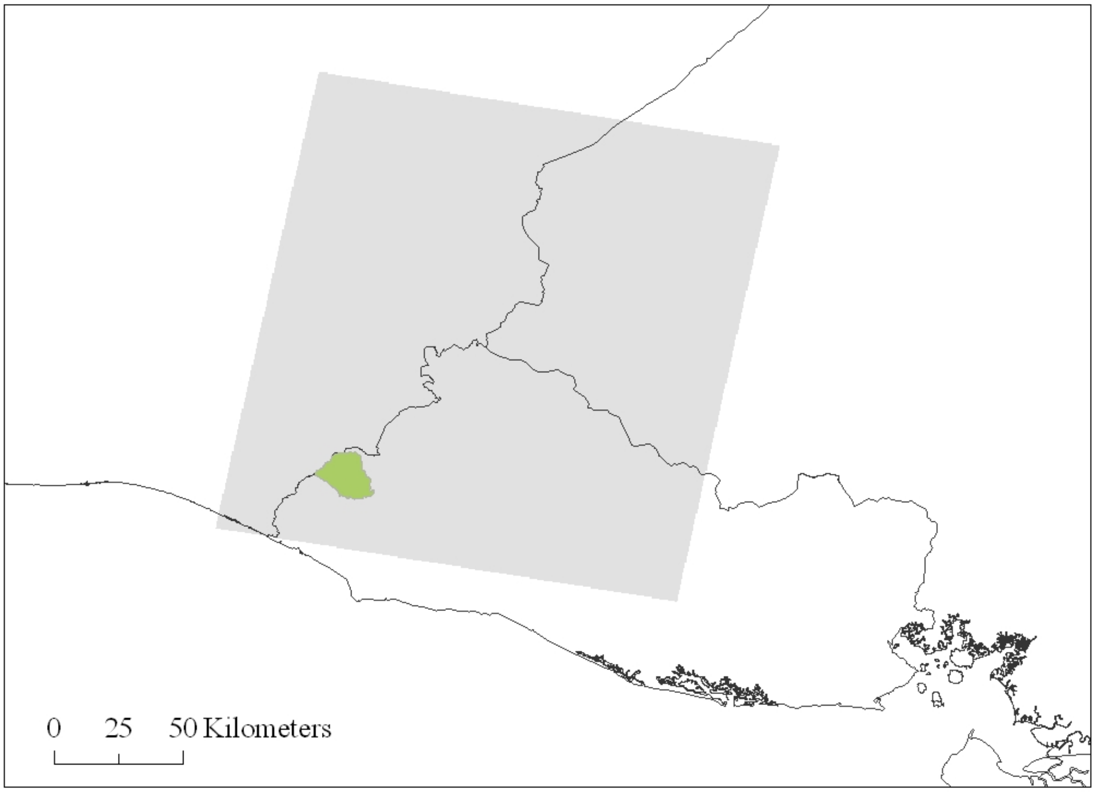

Figure 4.1. Location of the study area, Ahuachapán, Ahuachapán, El Salvador in relation to data (Landsat WRS Path 19/Row 50). Map by Jessica J. Kelly.

Landsat TM imagery was chosen in the analysis of forest cover change for several reasons. Landsat TM data has a ground-projected instantaneous field of view of 30 x 30 meters for the reflective bands of interest (bands 1, 2, 3, 4, 5, and 7).[10] With higher spatial resolution, land covers are more accurately classified. Landsat ETM+ data have the same spatial resolution as Landsat TM data, making it an appropriate selection in detecting temporal changes in land cover. However, the failure of the Scan Line Corrector (SLC) in May 2003 resulted in portions of unusable ETM+ data. Hence, Landsat data acquired after May 2003 were less reliable and excluded from the analysis.

[10] Spectral resolution of Landsat imagery: band 1 = .450-.515 µm; band 2 = .525-.605 µm; band 3 = .630-.690 µm; band 4 = .750-.900 µm; band 5 = to 1.55-1.75 µm; band 7 = 2.08-2.35 µm.

Data Collection

Data collection from field based visits was carried out in February to April, 2007. I collected ground control points in conjunction with household interviews using a global positioning system, a Garmin eTrex Legend. In addition, sketch maps were created simultaneously with ground-truthing and land use histories. Maps were produced with the help of residents of Cantón El Tigre. Sketch maps were used to distinguish orchards, living fences, and secondary forests from other land uses, as well as reproducing historical accounts of land cover.

Landsat Image Preparation and Pre-processing

Bands 3 (visible red), 4 (near infrared), and 5 (mid-infrared) were extracted from the original TM and ETM+ data sets to reduce processing time and space. Selecting the 3, 4, 5 band combination has been demonstrated as optimal in discriminating vegetation (Sader 1989). Unsupervised classification (ERDAS isodata) was carried out on Bands 3, 4, and 5 to produce 200 spectral clusters, creating binary images that allowed for the definition and isolation of water, clouds, and cloud shadows. The classes, being of no interest to forest cover change analysis, were masked and subtracted from the composite images to eliminate change detection due to noise.

Bands 1, 2, 3, 4, 5 and 7 for each of the two image dates were converted from digital numbers to radiance and reflectance, a technique known as radiometric normalization. This is a fundamental step in ensuring the data from different sensors were in a common radiometric scale (Chander and Markham 2003).

Classification and Change Detection Methods

This project aims to classify land cover in such a way that the most accurate accounting of forest (to include living fences, orchards, and secondary growth) versus non-forest land covers and detecting the change of those classes over time can be achieved. To do so, three independent methods for classifying forest and non-forest land cover types are carried out on the pre-processed images for 1986 and 2003. Then, the classifications are 'differenced' to detect change.

The goal of detecting changes in forest cover from temporal remotely sensed imagery is to effectively discriminate between those areas of interest across two or more images in a time series. The method of image differencing is a widely known method that subtracts the data values of one image from the spatially-linked data values of another. The resulting image allows the user to interpret the difference as changes, both positive and negative. The ease of this method is valuable in that it is highly accurate and simple in use and interpretation. Image differencing presents a set of challenges, as well. The user must define threshold values that help to differentiate between reliable and spurious results. Differencing only allows for the differencing of one band of data at a time.

Normalized Difference Vegetation Index: NDVI

To overcome the problem of single band change detection, vegetation indices have proven extremely valuable in forest change detection studies since indices are often ratios of bands (Jin and Sader 2005; Wilson and Sader 2002). Ratios of two bands are at times more effective in highlighting classes of interest like forest.

The Normalized Difference Vegetation Index (NDVI) was developed for use in identifying health and vigor in vegetation, as well as the estimates of green biomass, and has become a standard index for interpretation of changes in vegetation. NDVI measures the contrast between near infrared and red reflectance (bands 3 and 4 in Landsat).

An index image, of continuous data, was created by first calculating NDVI values for each date (j) of imagery by the following equation:

NDVI[j] = (TM4-TM3)/(TM4+TM3)

A difference image was created by subtracting one date of NDVI values from that of the previous date, so that:

DIF(1986 to 2003) = NDVI[2003] - NDVI[1986]

An accuracy assessment compared existing land cover classification maps (reference accuracies are 80%) from the Central American Environmental Program (PROARCA/APM)[11] to the results of the change detection via NDVI. An error matrix was developed to evaluate the ability of the method to detect change between forest and non-forest from 1986 to 2003. The results of the change detections were evaluated against a stratified random sample of 101 reference points.

Studies have shown that NDVI may not be the best predictor of biomass in tropical successional forests since large amounts of vegetation are rapidly forming, maximizing absorption of red radiation and reflectance of infrared radiation. Since NDVI relies on the differences between the two, the sensitivity of NDVI to biophysical properties is reduced (Boyd et al. 1996; Castro, Sanchez-Azofeifa, and Rivard 2003).

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[11] PROARCA (Programa Regional Ambiental para Centro América) is a conservation partnership of the Central American Commission on Environment and Development (CCAD), the United States agency for International Development (USAID), the International Resources Group, the Nature Conservancy, and Winrock International. The central aim of PROARCA is to strengthen the management of Central American parks within the Mesoamerican Biological Corridor.

Normalized Difference Moisture Index: NDMI

Recent studies suggest that the Normalized Difference Moisture Index (NDMI) that measures the contrast between mid and near infrared reflectance (bands 4 and 5 in Landsat) may be more sensitive than the more popular NDVI to revealing estimates for tropical succession because of NDMI's enhanced sensitivity to canopy moisture content, emphasizing the contrasts between mid and near infrared bands (Hayes and Cohen 2007; Jin and Sader 2005; Wilson and Sader 2002).

An index image, of continuous data, was created by first calculating NDMI values for each date (j) of imagery by the following equation:

NDMI[j] = (TM4-TM5)/(TM4+TM5)

A difference image was created by subtracting one date of NDMI values from that of the previous date, so that:

DIF(1986 to 2003) = NDMI[2003] - NDMI[1986]

An accuracy assessment compared existing land cover classification maps from PROARCA/APM to the results of the change detection via NDMI. An error matrix was developed to evaluate the ability of the method to detect change between forest and non-forest from 1986 to 2003. The results of the change detections were evaluated against a stratified random sample of 101 reference points.

The major difference between NDVI (index using red reflectance and near infrared--NIR) and NDMI (index using NIR and mid infrared—MIR) is in the absorption and reflectance properties of green vegetation. NDVI discerns green vegetation from other land covers because green vegetation absorbs visible red wavelengths and reflects NIR wavelengths (Tucker 1979). High NDVI values are correlated with forest cover

(Sader and Winne 1992). The success of NDVI in accurately detecting forest cover and the ease of computation have made NDVI a popular choice in forest cover change analysis (Myneni and Asrar 1994). NDMI is less popular in usage; however, NDMI has proven significantly more accurate in detecting forest cover change than NDVI (Wilson and Sader 2002). By comparison, green vegetation reflects NIR, but MIR absorbs water. Reflectance of MIR and reflection of NIR is approximately equal for dry leaves, and reflectance of MIR is less than reflectance of NIR when water is better absorbed. The higher absorption of MIR is correlated with fresh "green" leaves (Hunt, Rock, and Nobel 1987). The advantage of NDMI over NDVI could be in the ability to better differentiate between less green forests (i.e. emerging secondary forests, orchards, and living fences) from saturated green forests (i.e. dense, long-standing and primary forests) since NDVI is less capable of differentiating between levels of "greenness."

Cluster Analysis

In cluster analysis, the two images were classified to improve separation between forest and non-forest land cover types, with particular emphasis on separating agro-forestry, orchards, living fences, and secondary growth from other non-forest types. An unsupervised classification (ERDAS isodata) was carried out on the normalized 1986 and 2003 images (bands 1, 2, 3, 4, 5, and 7) and 30 discrete data classes were each assigned forest or non-forest in the signature editor using training sites developed from the ancillary[12] data: collected GPS points, sketch maps (based on land use histories from interviews), and aerial photographs. Change detection analysis was carried out on the

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[12] Ancillary data, or collateral data, often refers to digital elevation models, soil maps, geology maps, political boundary files, etc. that are used in the remote sensing analysis process to improve interpretation.

classified images to produce images highlighting conversions of forest to non-forest and non-forest to forest.

An accuracy assessment compared existing land cover classification maps from PROARCA/APM (1998) to the results of the cluster analysis. An error matrix was developed to evaluate the ability of the method to discriminate between forest and non-forest for 2003. The result of the classification was evaluated against a stratified random sample of 250 reference points.

IV. Results and Discussion

Results of forest clearing and recovery, derived from change detection analysis using NDVI, NDMI, and cluster analyses suggest that significant differences exist in the estimates of forest cover change depending on the method of analysis chosen. The objective here is to assess how forest cover is changing in Ahuachapán and which method(s) are best for detecting that change.

NDVI and NDMI

The effective use of remotely sensed data as a tool for generating information about forest cover change is highly dependent on the accuracy and quality of the interpretation of that data. Results of the NDVI and NDMI, when compared, demonstrate that the range of values is slightly greater for NDMI than for NDVI (see Figure 4.2). NDVI and NDMI are both indices that produce a single image of continuous data. The analyst is set to the task of determining which values represent forest and non-forest. For both, values closest to 1 likely represent forest cover. However, there is some question as to where the lower threshold would be set to distinguish between forest versus non-forest.

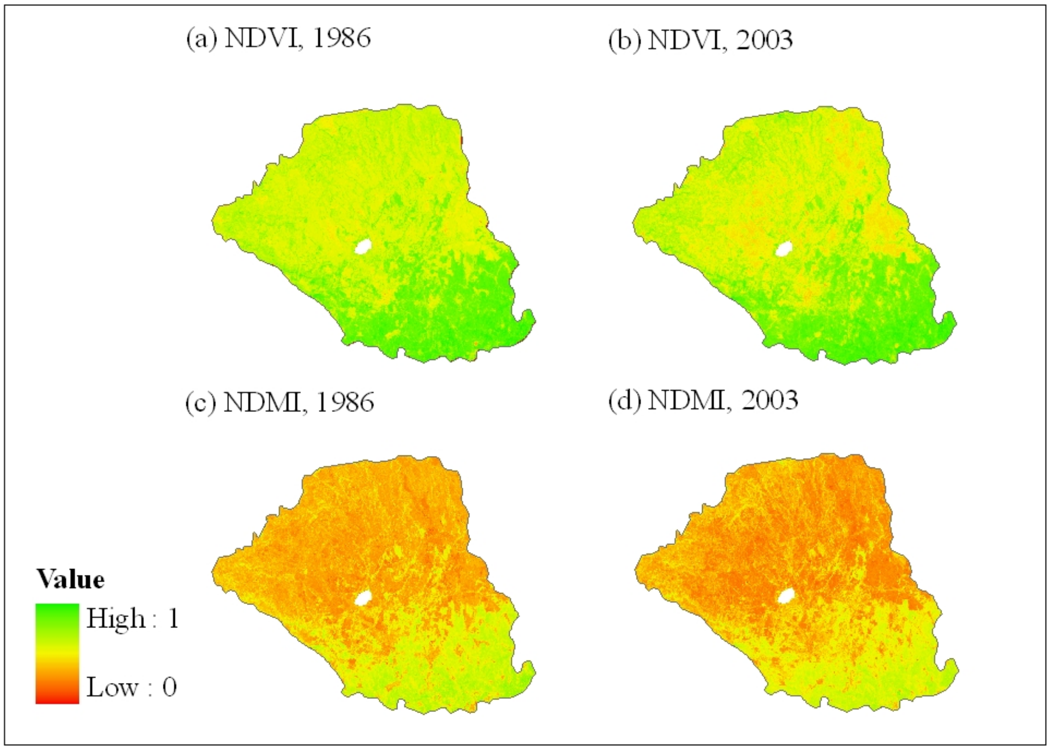

Figure 4.2. NDVI and NDMI for Ahuachapán, El Salvador, 1986 and 2003.
Map by Jessica J. Kelly.

To measure forest cover, the analyst determines the threshold values for forest and non-forest. However, since the primary objective here is to assess forest cover change, the results of the change detection were more significant in determining threshold values.

NDVI and NDMI increase where non-forest is being converted to forest land cover, and NDVI and NDMI decrease where forest is being converted to non-forest land cover. However, not all changes in NDVI and NDMI account for increases or decreases in forest cover.

Likewise, determining the threshold in change detection using NDVI and NDMI can be challenging. In Figure 4.3, the change detection of NDVI reveals extensive decrease in NDVI and little increase at both 10% and 15% change thresholds. NDMI reveals a very different spatial distribution of change at the same change thresholds. Still, the analyst must determine at what threshold of change meaningful conversion of land cover occurs. Significantly different estimates of forest cover change would be ascertained based on the threshold selected (see Table 4.1).

Table 4.1. Total area (sq. km) of change in values, NDVI and NDMI.

	Change in Threshold Value			
	>10% increase	>10% decrease	>15% increase	>15% decrease
NDVI	11.28	63.51	4.55	24.14
NDMI	15.50	27.07	5.69	8.06

The year 2003 was a mild El Nino year in El Salvador. Given these conditions, some decrease in values of NDVI and NDMI without an actual land cover conversion of forest to non-forest occurring would be expected. However, increases in NDVI and NDMI values are more likely to be conversions of non-forest to forest, since 2003 conditions would be drier than normal. Also since April still represents the dry season, agriculturalists did not yet begin planting for the season.

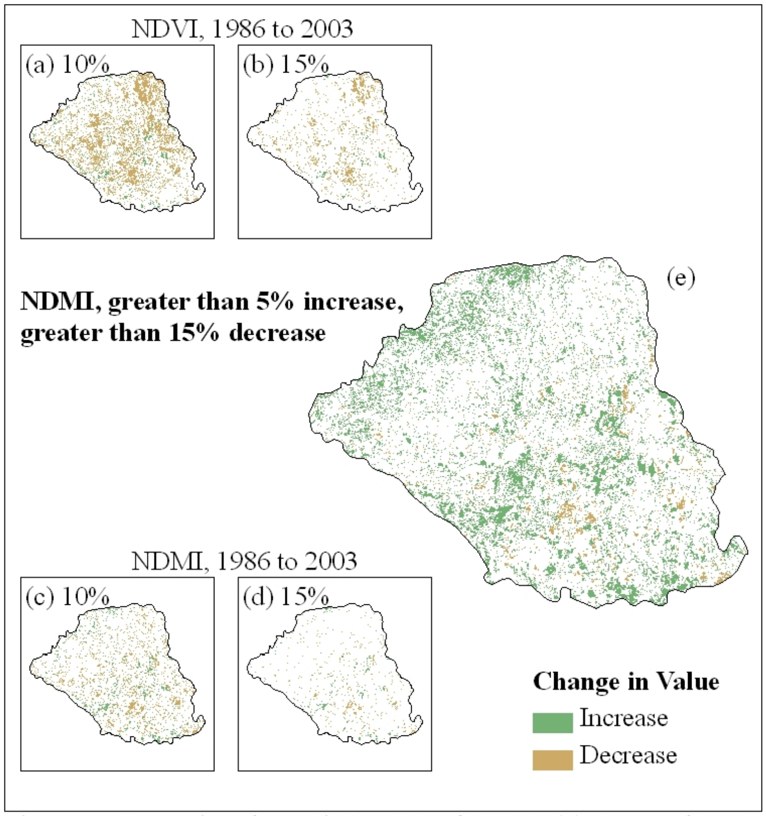

Figure 4.3. Detecting change in NDVI and NDMI. (a) Greater than 10% change in NDVI value; (b) Greater than 15% change in NDVI value; (c) Greater than 10% change in NDMI value; (d) Greater than 15% change in NDMI value; (e) Greater than 5% increase and greater than 15% decrease in NDMI value. Map by Jessica J. Kelly.

Thresholds were selected for greater than 5% increase and greater than 15% decrease in values of NDMI and 10% increase and 10% decrease in NDVI. The increase/decrease thresholds were selected by evaluating the standard deviation of NDMI and NDVI values. Change was determined by examining the tails of a normal distribution (with the mean value at zero representing no change).

The accuracies (see Table 4.2 and 4.3) of the change detection were carried out on both change detections for NDVI and NDMI. The overall accuracies of NDVI and NDMI were 50.50% and 57.43% respectively. The Kappa coefficient, which measures the percentage improvement by the classifier over a purely random assignment of classes, suggests that accuracy is rather low for both NDVI and NDMI. However, the output has been compared to already classified map that has an estimated accuracy of 80%, and should be considered in the assessment of accuracy here.

Since class accuracies of not less than 70% are generally accepted (Thomlinson, Bolstad, and Cohen 1999), a more careful examination of the particular classes may be useful. The user accuracy for the forest class is more important as the objective is concerned with forest changing. For NDVI, the user accuracy for forest (or those values that increased by greater than 10%) is 64.44%. However, NDMI outperforms NDVI significantly in that the user accuracy for forest (or those values that increased by greater than 5%) is 82.00%. User accuracy of non-forest land cover types for both NDVI and NDMI are comparable at 53.66% and 56.67% respectively.

Table 4.2. Error matrix of NDVI vs. NDMI for Ahuachapán municipality, 2003.

NDVI, Increase (Forest) versus Decrease (Non-forest), 2003				NDMI, Increase (Forest) versus Decrease (Non-forest), 2003			
	Reference Data				Reference Data		
Classified Data	Forest	Non-forest	Row Total	Classified Data	Forest	Non-forest	Row Total
Forest	37	18	55	Forest	49	16	65
Non-forest	22	24	46	Non-forest	14	22	36
Column Total	59	42	101	Column Total	63	38	101
	Overall Accuracy = 50.50% Kappa = .1329				Overall Accuracy = 57.43% Kappa = .2653		

Table 4.3. Accuracy totals of NDVI vs. NDMI for Ahuachapán municipality, 2003.

NDVI, 2003				NDMI, 2003			
Class Name	Ref. Total	Class. Total	# Correct	Class Name	Ref. Total	Class. Total	# Correct
Forest	59	45	29	Forest	63	50	41
Non-forest	42	41	22	Non-forest	38	30	17
Producer Accuracy	49.15% Forest 52.38% Non			Producer Accuracy	65.08% Forest 44.74% Non		
User Accuracy	64.44% Forest 53.66% Non			User Accuracy	82.00% Forest 56.67% Non		

Cluster Analysis

Cluster analysis relied heavily upon the use of ancillary data which was derived from a variety of sources: GPS recorded sites from field visits, sketch maps from land use histories, and aerial photographs. The unsupervised classification produced 30 thematic clusters which were assigned on the basis of reference to the ancillary data. Sketch mapping is a method gaining wider acceptance as remote sensing analyses have been improved when linked to local-scale land change (Roy Chowdhury and Schneider 2004). Figure 4.4 illustrates the results of pairing sketch maps (a) that detail forest and non-forest land cover classes with GPS points on the normalized imagery (b). In bands 5, 4, and 3, vegetation appears green.

After the unsupervised classification produced the clusters, the ancillary data was used to re-code each of the classes as forest or non-forest. In Figure 4.4(c), a unique values map illustrates the individual classes before being recoded. Since ground-truthed data was limited to part of the study area, ancillary data in the form of aerial photographs helped to ensure a spatially distributed set of sites to improve confidence in recoding classes.

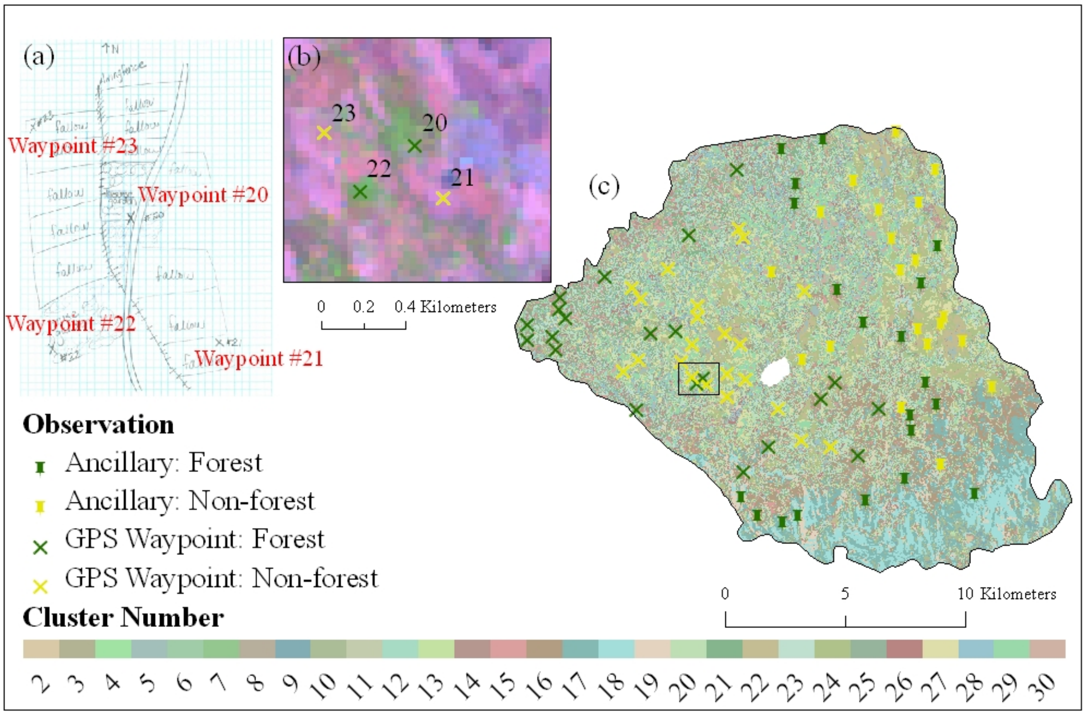

Figure 4.4. Assigning clusters as forest or non-forest using field observation (GPS) and ancillary data (aerial photographs). (a) Sketch map; (b) Bands 5, 4, and 3 of Landsat ETM+, 2003; (c) Selection of GPS waypoints and ancillary data to assign clusters as forest or non-forest. Map by Jessica J. Kelly.

The result of recoding the clusters is a thematic map of forest and non-forest classes (see Figure 4.5). Typically, ancillary data are used to develop training sites to be input into a supervised classification where training sites correspond to land cover signatures. Since a relatively low number (~100) of training sites from GPS and sketch-mapping alone were available, the unsupervised approach was more likely to produce a correct classification.

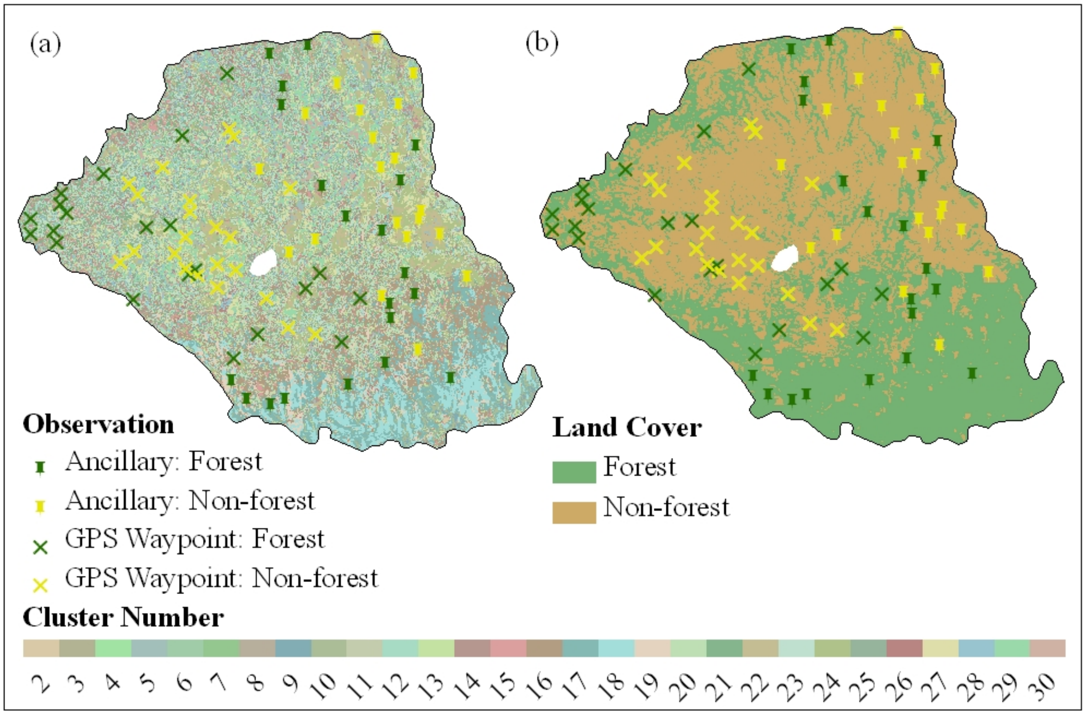

Figure 4.5. Classificiation of forest and non-forest uses for 2003, using cluster analysis. (a) Selection of GPS waypoints and ancillary data with clusters, 2003. (b) Forest and non-forest classification, 2003. Map by Jessica J. Kelly.

The cluster analysis resulted in an overall accuracy of 74.40% and Kappa coefficient of .4869. While still lower than acceptable classification accuracy standards, the cluster analysis shows marked improvement over NDVI and NDMI (see Table 5.4). Considering also that the accuracy assessment is compared to a reference map with reported accuracy of approximately 80%, the results are appropriate. In addition, a GIS overlay was employed to assess the validity of the cluster analysis on a per pixel basis. When compared to the reference map, results in disagreement of land cover class by only 15.34% of the total land area.

A closer look at the accuracy totals in Table 4.5 reveal that NDMI still outperforms the cluster analysis when referring to the user accuracy for the class of interest, forest. In the cluster analysis, the user accuracy is slightly less at 76.74%

compared to NDMI's 82.00%. The cluster analysis demonstrate less variation, and producer accuracies and user accuracies range between 71.90 and 76.74% for both forest and non-forest classes.

Table 4.4. Error matrix of classifications for Ahuachapán municipality, 2003.

Cluster Analysis, Forest versus Non-forest, 2003				NDMI, Forest versus Non-forest, 2003			
	Reference Data				Reference Data		
Classified Data	Forest	Non-forest	Row Total	Classified Data	Forest	Non-forest	Row Total
Forest	99	30	129	Forest	49	16	65
Non-forest	34	87	121	Non-forest	14	22	36
Column Total	133	117	250	Column Total	63	38	101
	Overall Accuracy = 74.40% Kappa = .4869 Area of Disagreement = 15.34%				Overall Accuracy = 57.43% Kappa = .2653		

Table 4.5. Accuracy totals of cluster analysis vs. NDMI for Ahuachapán municipality, 2003.

Cluster Analysis, 2003				NDMI, 2003			
Class Name	Ref. Total	Class. Total	# Correct	Class Name	Ref. Total	Class. Total	# Correct
Forest	133	129	99	Forest	63	50	41
Non-forest	117	121	87	Non-forest	38	30	17
Producer Accuracy	74.44% Forest 74.36% Non			Producer Accuracy	65.08% Forest 44.74% Non		
User Accuracy	76.74% Forest 71.90% Non			User Accuracy	82.00% Forest 56.67% Non		

NDMI then appears to be a valuable approach in detecting new forest; however, the benefit of ancillary data or ground truth data supports the claim that remote sensing analysis is improved when tied to local knowledge. Future studies might incorporate

NDMI and cluster analysis with ancillary data together to improve the estimates of forest cover and forest cover change.

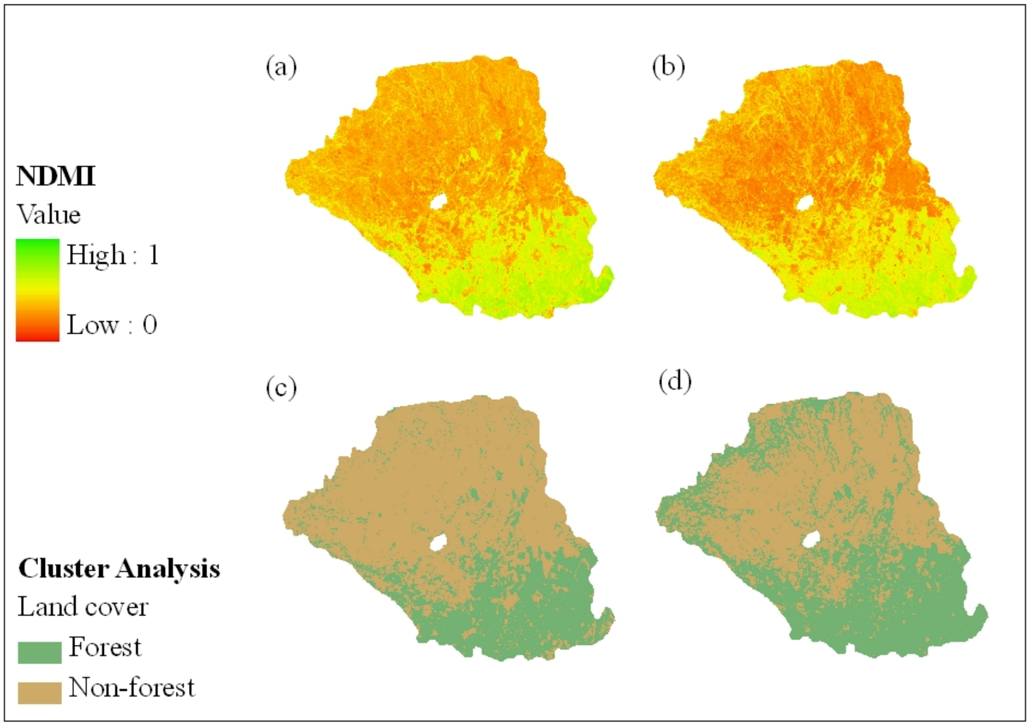

Figure 4.6. Continuous and discrete land cover classes for Ahuachapán, El Salvador: (a) NDMI, 1986; (b) NDMI, 2003; (c) Cluster analysis, 1986; (d) Cluster analysis, 2003. Map by Jessica J. Kelly.

The outputs of both NDMI and cluster analysis classification are presented in Figure 4.6. The spatial distributions of forest in cluster analysis correlate with higher values of NDMI. Overall, NDMI and cluster analysis are appropriate methods for detecting forest cover and forest cover change in El Salvador. Therefore, both NDMI and cluster analysis may be used to test the original hypothesis.

Estimates of forest cover and forest cover change from 1986 and 2003 are quantified in Table 4.6. NDMI results in net forest increase of 36.38 sq. km. Cluster analysis results in net forest increase of 38.77 sq. km. The difference between the two estimates is 0.8% of the total land area of the municipality. Both suggest that forest cover is increasing in the municipality of Ahuachapán, El Salvador.

Table 4.6. Forest cover change by method for Ahuachapán municipality, El Salvador.

	NDMI			Cluster analysis				
	Increase	Decrease		2003		1986		
	Greater than 5% increase 1986-2003	Greater than 15% decrease 1986-2003	Net forest cover change 1986-2003	Class forest	Class non-forest	Class forest	Class non-forest	Net forest cover change 1986-2003
Total Area (km^2)	44.93	8.06	36.87	119.38	143.87	80.61	182.64	38.77

Land use transitions, such as forest transition, imply that a land use is converted to another. Using remote sensing, forest transition is tested by examining conversions of forest covers. The results of the classification analysis and change detection or conversion (see Figure 4.7) indicate that forest cover change in Ahuachapán is likely the result of conversion of agricultural lands to agro-forestry uses, the growth of living fences, and some secondary forest growth since much of the new forest from 1986 to 2003 is concentrated on land classified as non-forest in 1986 and most non-forest to forest conversions are occurring in areas furthest from standing forests of 1986. Some forest cover change is also occurring adjacent to standing forests of 1986; however, conversions of forest to non-forest are primarily occurring closest to standing forest of 1986.

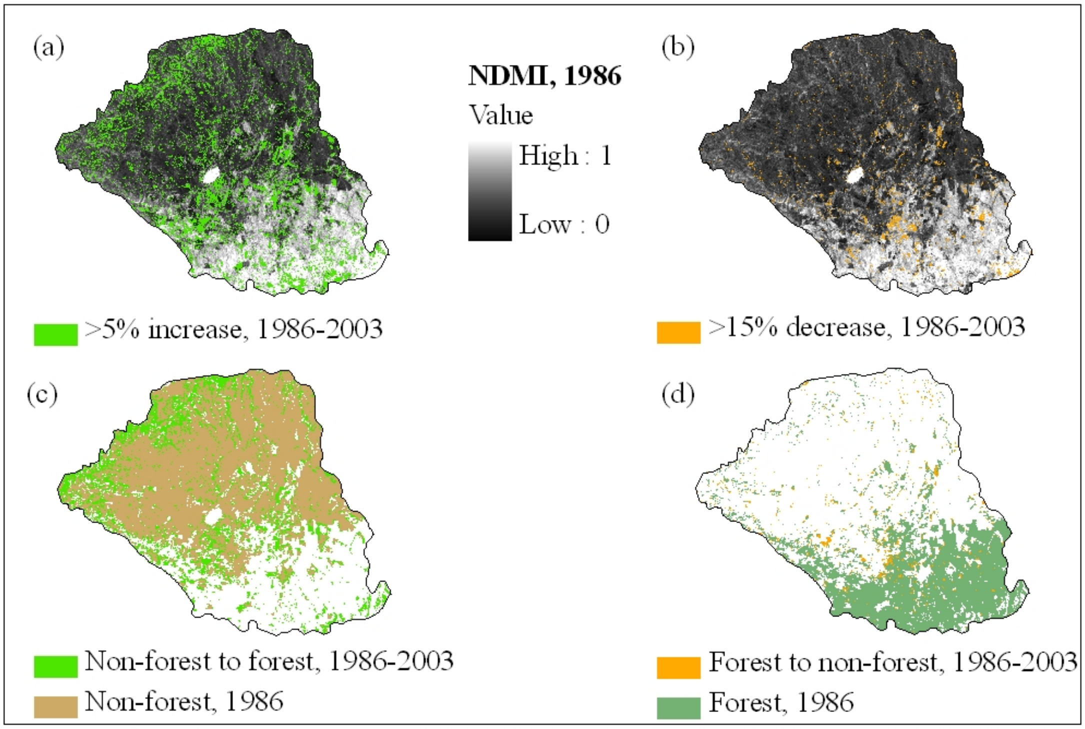

Figure 4.7. Land cover transitions, 1986-2003. (a) Greater than 5% increase in NDMI value, 1986-2003; (b) Greater than 15% decrease in NDMI value, 1986-2003; (c) Change from non-forest (1986) to forest (2003), derived from cluster analysis; (d) Change from forest (1986) to non-forest (2003), derived from cluster analysis. Map by Jessica J. Kelly.

NDMI may be important for helping the user to examine some areas of the imagery more carefully and with the aid of aerial photographs and/or ground-truthing when completing a classification analysis. NDMI potentially allows the user to identify more readily areas that may or may not be experiencing secondary growth and forest clearing. The addition of NDMI to cluster analysis may improve overall accuracy of the cluster analysis of forest and non-forest land cover classes. However, ancillary data was best for improving the overall accuracy of the estimates.

In addition, the results indicate that measures of forest cover change in El Salvador may not be as accurate with 30-m resolution imagery. In detecting early changes or perhaps the turning point in the forest transition theory, 30-m resolution may be too coarse. Rather, higher-resolution imagery may be more appropriate in areas where high density land use continues to be concentrated, and where the analyst wishes to liberally define forest and forest cover (i.e. living fences) in the analysis. Where stricter definitions of forest are used, Landsat imagery is probably most appropriate.

In employing more liberal definitions of forest, El Salvador is experiencing forest cover increase, based on the results on analysis in Ahuachapán. However, the drivers of such change are not reflected here. To begin to examine the possible drivers of such change and the implications for gender in forest transition theory, national level forest cover change is coupled with socio-economic data in regression analysis in chapter 5.

Chapter V: Regional Patterns of Drivers and Forest Cover Change in El Salvador

Introduction

Forest transition theory was originally formulated to describe long-term forest change dynamics at a high order of aggregation (i.e. the national scale or greater). Recent calls to test forest transition theory using a complex, scale-dependent, interdisciplinary approach (Perz 2007) have been challenged on the basis that such approaches are not as revealing for forest transition theory as empirically-driven methodologies rooted in geographic thought (Walker 2008b). Yet, regional science and other positivist approaches have been thoroughly criticized for employing formal statistical techniques that do not reflect the nature of the 'real world' (Holland 1976), nor the relationships between the fixed and often arbitrary spatial scale of the units of analysis (i.e. political units). Others have suggested that analyses at scales between the global and local may be best in assessing the drivers of forest cover change in the tropics (Meyer and Turner 1992).

In previous chapters, I explore forest cover change at the local level. Now, I link forest cover change (at 500-m spatial resolution) to department-level and municipal-level census data in El Salvador. Because land cover (as detected by remote sensing) is not synonymous with land use, methods for incorporating remotely sensed data with socio-economic and demographic data are becoming more important in studies surrounding land use and land cover change (Geoghegan et al. 1998). Accounting for the spatial nature (Bockstael 1996) of forest recovery in El Salvador will improve estimation of the power of predictor variables in forest cover change. The key purpose of this chapter is to describe the relationship between forest cover change and several socio-economic, demographic and spatial variables and to discuss the path of forest transition in El Salvador. By bridging census-derived data and remotely sensed data on forest cover change, multivariate analyses of forest cover change and social, economic, and spatial data describe the correlation between potential drivers and reforestation in El Salvador. Finally, regional analyses of drivers and reforestation provide a case for the methods of regional science and for the methods that are complex and interdisciplinary.

I. Considerations for Regional Change Analysis and Determinants of Forest Cover Change in El Salvador

Scholars have recognized the importance of linking socio-economic phenomena to biophysical land cover changes (Wilbanks and Kates 1999). Such studies reveal important dynamics that are essential to understanding human-forest interactions (Turner 1997). Because land use and land cover changes also create potential hazards and vulnerabilities to people in the form of climatic, economic, social, and political change (Kasperson, Kasperson, and B. L. Turner 1995; Turner et al. 2003), the relationship between these factors at higher-order scales are of particular interest. Regression approaches to land use and land cover change potentially explain relationships between observed values of forest cover change and social economic and political phenomena; and as such, they are supported as effective in methodology (Kok 2004; Nagendra 2007; Overmars and Verburg 2005). The purposes of such analyses have been intended to improve the explanation for forest cover change and to improve the predictions for future change in forest cover (Verburg et al. 2006).

Social and economic processes, driven by actors, often operate at different scales than biophysical processes, and consequently, data comparison is not without complications (Veldkamp and Lambin 2001). Multi-scale regression analyses are complicated in that statistical methods, such as regression analysis, assume the data to be independent. The assumption is problematic since municipalities, regions, and states do not exist in a vacuum. Spillover effects across the spatial units are predictable (Overmars, Koning, and Veldkamp 2003), and changes in adjacent municipalities contribute to changes in each. Thus, spatial autocorrelation, or the correlation of forest cover change in one municipality with that in a neighboring municipality, is highly probable (Anselin 2002; Getis 2008).

Despite the drawbacks of the proposed methods, developing a solid understanding of the factors that influence forest change is essential to ensuring continued forest recovery (Nagendra 2007), if in fact reforestation is the dominant trend in El Salvador. While simple, reduced-form models will be implemented here, the intention is not to oversimplify the complex, multi-scalar determinants of forest cover change, nor to perpetuate myths associated with the causes or consequences (Lambin et al. 2001) of forest cover change. Instead, empirical tests potentially ground the theoretical discussions of the likely paths of forest recovery in El Salvador (see chapter 2).

The predictor variables proposed here represent a small selection of factors that drive forest cover change, but they provide sufficient variation to allow for an examination of various contexts related to the two major paths of forest transition: economic development path and the forest scarcity path. The predictor variables were chosen on the basis of theorized patterns of social and political phenomena in El

Salvador, and the methodological scales at which the variables are measured are largely driven on the basis of data availability. A rationale for the selection of these variables is presented below.

Region and Distance to San Salvador

Sub-national regional differences in El Salvador have been demonstrated to influence forest cover change in El Salvador already. In a study of forest cover change near three major coffee-growing areas in El Salvador, Blackman and others found that regression results of forest cover change differed across three coffee regions (located in the west, central and eastern zones) because underlying differences existed in the regions' characteristics. In particular, the coffee region just south of San Salvador, was dominated by the capital city, so much of the land could be characterized as peri-urban; whereas, two other coffee growing regions found in the east and west differed in that cities there were significantly less dominant and surrounding land less peri-urban (Blackman, Avalos-Sartorio, and Chow 2008). These findings suggest that regional differences will be significant to the patterns of overall forest cover change in El Salvador. In addition, any analysis that incorporates "region" as a driver of forest cover change would take into account multiple characteristics held in common, including physical and cultural attributes. An explanation of the region variable is described in the methods section of this chapter.

Regression models that specifically account for location have been used to explain patterns of forest cover change with findings that proximity to urban centers and roads are significant for forest cover change (Kaimowitz and Angelsen 1998).

Proximity or distance to the primate city and capital, San Salvador, would serve as a proxy variable to understand the deeper underlying force of the influence of the major marketplace in El Salvador.

An anticipated problem of incorporating this variable is that causality may be obscured (Veldkamp and Lambin 2001), and the assumption is that San Salvador is the sole influencing market[13]. At the national scale, San Salvador is the major market of the country, but regional cities are significant on the sub-national and local scales (i.e. Ahuachapán, Santa Ana, Sonsonate, San Miguel, and Usulután).

Population Density, Gender, Migration, and Agriculture

Population change and population density have been used to estimate forest cover change in rural areas (UNFCCC 2006) when forest cover estimates are not available. However, to use population change as a substitute measure of forest change is problematic in that forest cover change may or may not be accompanied by dramatic changes in population. Using population change or population density, alone, does not fully capture the dynamics of forest cover change, but rather using population variables alone perpetuates the myth that population growth equals forest clearing (Lambin et al. 2001). The relationship between population change and forest cover change is not necessarily linear as demonstrated by Curran and Agardy.

[13] The metropolitan area of San Salvador makes up approximately 25% of the total population of El Salvador, and 7% of the total country population lives in the city limits of San Salvador (DIGESTYC, 2006).

> The demographic phenomenon is not population growth or a change in numbers, but an underlying process that affects population size and growth rates: i.e. migration and associated social relations that result from or cause more migration. …[T]here is a nonlinear link between population and environment, which when explored reveals the importance of understanding how individuals and communities are embedded in sets of social relations that must be considered when evaluating environmental policies or when determining the causes of environmental degradation. (Curran and Agardy 2002)

Population density should still be considered, in part, since several studies suggest that where population declines or where population density is low/decreasing, forests recover (Mather 1992; Klooster 2000). Likewise, high population density has also been observed alongside successful agro-forestry (Tiffen, Mortimore, and Gichuki 1994).

Because of socioeconomic globalization and out-migration from the rural tropics, forest recovery may be explained by households withdrawing participation from many agricultural activities, primarily cultivation (Schmook and Radel 2008; Hecht et al. 2006; Aide and Grau 2004). Yet, agriculture remains an important economic activity in El Salvador. Out-migration from the rural tropics has historically been linked to the expansion of extensive agricultural activities in the form of pasture land and cattle operations (Jokisch and Lair 2002; Taylor, Moran-Taylor, and Ruiz 2006; Sloan 2007). In some parts of El Salvador, this may be true, but for other areas, as discussed previously, gender and land tenure likely plays a more important role since the northern and western regions of El Salvador are not well suited, because of topological characteristics, for cattle ranching.

An exploration of the differences between male and female participation in agriculture may indicate that gender plays a significant role in forest recovery, since gender has played a critical role in other studies surrounding the gendered nature of agriculture (Rocheleau and Edmunds 1997; Schroeder 1998; Tiffen, Mortimore, and Gichuki 1994). In the case for El Salvador where rural women are increasingly taking on the role of heads of household as a result of out-migration of males abroad (see chapter 2), one may hypothesize that women are increasingly engaging in agro-forestry in rural areas where tenure is secure (and their participation in agricultural employment is high) or that women are clearing land to maintain their presence on the land in the case where land tenure is insecure. Tree farms are becoming more common in rural places where croplands are being converted and where land tenure is reasonably secure (Rudel 2009), and women are more likely to participate in these non-traditional forms of agriculture than in row cultivation (dominated by men in El Salvador). The intentional planting of trees may help to make claims to land stronger.

Here, in-migration to a municipality may be relevant to capture these effects as men dominate rural-to-rural migration. Most often, men migrate to rural areas in search of work in agriculture, suggesting that reforestation is less likely to occur where the rate of male migration to rural areas is high. Women, however, dominate the migration flows in the case of rural-to-urban migration in El Salvador. Yet, one may expect that forest recovery is least likely to occur in urban areas compared to rural areas. What is unclear is what happens to forest cover change when rates of female migration to other rural areas are high.

II. Hypotheses

Since forest transition theory is meant to describe net forest cover change at the national level, national analysis of forest cover change as it relates to population density, sex ratio, employment in agriculture, gendered migration patterns, and proximity to the primate city, San Salvador, are examined. In addition, regional patterns in El Salvador are considered in the analysis.

The following hypotheses are tested for statistical significance: (1) forest recovery is occurring in El Salvador; (2) there are differences between male and female rates of formal participation in the agricultural sector in El Salvador; (3) there are differences between male and female rates of migration in El Salvador; (4) population density, sex ratio, gendered employment in agriculture, gendered migration, and proximity to urban areas drive forest cover change in El Salvador; and (5) regional patterns in population density, sex ratio, gendered employment in agriculture, gendered migration, and proximity to urban areas drive forest cover change in El Salvador.

III. Methodology

Study Area and Background

El Salvador, at the national scale, is experiencing a net increase in forest cover (Hecht and Saatchi 2007). Municipalities, the primary units of the analyses, were assigned a region based on similar characteristics in out-migration patterns and remittance incomes, history of civil conflict, general landholding patterns, and characteristics of the physical landscape, including terrain and soil quality. Regions (see Figure 5.1) were generated from compilations of several sources (Beverley 1982;

Blackman, Avalos-Sartorio, and Chow 2008; Cuellar 2005; Deere 2001; Gammage, Benitez, and Machado 2002; Hecht 2004; Hecht et al. 2006; Hecht and Saatchi 2007; Mendez, Gliessman, and Gilbert 2007; Paige 1997; PRISMA 2002; Reyes 2007). These regions are different from the zones described in earlier chapters. Since the patterns of social, political, and physical phenomena do not exactly correspond to the zonal or departmental boundaries, new regions are homogeneous in the characteristics of interest here.

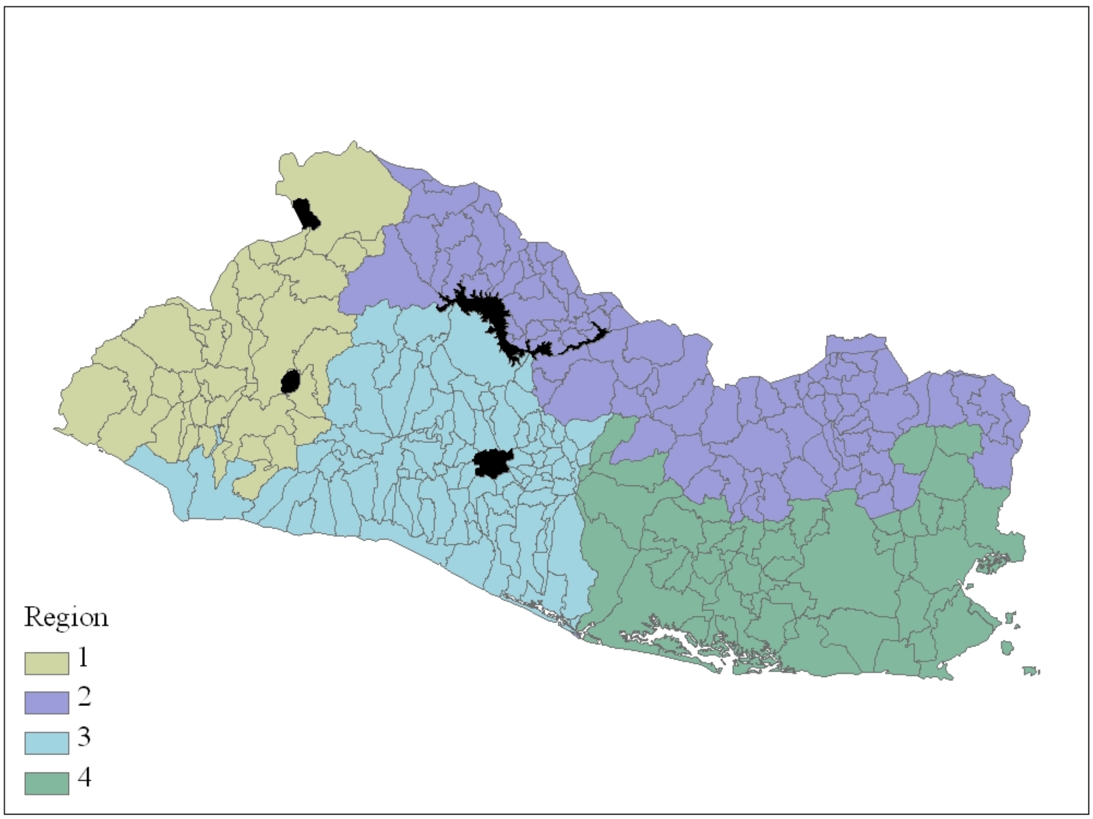

Figure 5.1. Regionalization of El Salvador. Map by Jessica J. Kelly.

Region 1 encompasses most western municipalities in the departments of Ahuachapán, Sonsonate, and Santa Ana with the exception of several municipalities along the coast of the Pacific Ocean. The region can be generally characterized as a region containing the majority of natural forests in several national forested parks (El

Imposible, Montecristo, and Los Volcanes). Historically, major coffee plantations dominated the region, and coffee is still today a major economic activity here. Of the four regions, Region 1 was perhaps least impacted by the civil conflict of the 1970s and 1980s. The region has had a history of low levels of out-migration and correspondingly low levels of remittances. Major cities include Ahuachapán and Sonsonate, but much of the land in the region is characterized as rural outside of the major urban centers. Landholding patterns are a mix of reform cooperatives, private cooperatives, and smallholdings in rural areas. Land tenure is considered fairly secure in Region 1, though many parcels may remain untitled.

Region 2 includes municipalities along the northern tier with several bordering Honduras. The region represents the area of the country most severely affected by the civil war, including municipalities in Chalatenango, Morazán, San Miguel and La Unión. Because of the history of several of these municipalities as rebel strongholds, many areas were targeted by government supported death squads. Out-migration from this region to destinations abroad was very high during the 1980s and 1990s, and today, the region receives moderately high remittances. With few major cities, much of the land is rural, and with poorer soils and steeper terrain, commercial agriculture is limited. Land tenure is least secure here compared to the remainder of the country.

Region 3 is the core of the country, consisting of mostly urban and peri-urban land uses. San Salvador and several satellite cities are centrally located here, and population density is significantly higher than in other parts of the country. San Salvador experiences high in-migration from other parts of the country. Land tenure is highly secure, and peri-urban commercial agriculture dominates areas outside of the metropolitan area.

Region 4 is dominated by logging, ranching, and commercial cultivation in the interior. Aquaculture is important here along the Pacific coast as well. Urban land uses are minimal compared to regions 1 and 3. From this region, high out-migration was common during the civil conflict as the area was also heavily influenced by changes as a result of the civil war. Historically, the region is marked by heavy land clearing and extensive commercial agriculture. Remittances are highest in the region compared to the rest of the country.

To investigate the significance of the region or whether some regions have a stronger relationship between the predictor variables and forest cover change, I employed a set of dummy variables (DUM_1; DUM_2; DUM_3; and DUM_4) representing each of the four regions.

Data Sources

Forest cover change (FOR_CHA) is the dependent variable in the analysis. Detecting forest cover change remotely for El Salvador presents challenges (see chapter 5). El Salvador is not captured in its entirety by a single scene of Landsat TM, the preferred spatial resolution for optimal land cover classification. MODIS imagery that captures El Salvador in a single scene is coarser in resolution, but MODIS is effective in detecting the spatial distribution or extent of forest cover. MODIS provides long-term observations and views the entire surface of the Earth every 1 to 2 days. I obtained the publicly available tree cover estimates product, Moderate Resolution Imaging

Spectroradiometer (MODIS) Vegetation Continuous Fields Algorithm[14], for 2000 and 2005 at 500-m resolution (Hansen et al. 2006a, 2006b) with coverage for all of El Salvador in one tile (PN1516).

Socio-economic data from El Salvador's 1992 census[15] were collected for 262 municipalities that comprise the 14 departments in El Salvador. Secondary data collected include population, population density (PDENS), population by cohort and sex, economic activity in agriculture (AG_EM), and migration that were available at the municipal and department levels. Additional variables were derived from the data for the purposes of enhancing the statistical analysis: percentage female population employed in agriculture (F_AG), percentage male population employed in agriculture (M_AG), percentage female population in-migrating (F_INMIG), percentage male population in-migrating (M_INMIG), and sex ratio (SEXRCO) (see Table 5.1). The initial suite of variables was selected on the basis of their representation of the processes believed to be driving forest cover change in El Salvador.

[14] The Vegetation Continuous Fields collection contains the estimates for tree cover as a percentage of each pixel (500m x 500m), as well as other vegetation cover types. The product that estimates tree cover was derived from the MODIS visible bands to discriminate tree cover; though the collection of products was derived from all seven bands of MODIS sensor aboard NASA's Terra satellite. The MODIS continuous fields of vegetation cover algorithm (Hansen et al. 2002) was used to develop a more accurate characterization of tree cover at a finer scale of 500-m resolution compared to earlier estimates that relied on AVHRR data at 1-km resolution. (http://glcf.umiacs.umd.edu/data/vcf/)

[15] The census is conducted under the authority of the Dirección General de Estadística y Censos (DIGESTYC). El Salvador completes a census every 15 years; however, the most recent census was completed in 2007. Data of interest in this analysis were not yet available to the public at the time of analysis.

Table 5.1. Data sources and measures for analysis of drivers and forest cover change, El Salvador

Variable	Unit of measurement	Scale**	Year	Source
Socioeconomic data				
PDENS-population density	Inhabitants/sq.km.	M,D	1992	DIGESTYC, 1992
SEXRCO-sex ratio, cohort 25-40	Males: Females (age 25-40)	M,D	1992	Derived, DIGESTYC, 1992
AG_EM-agricultural workers	%age of population	M,D	1992	DIGESTYC, 1992
AG_F-female agricultural workers	%age of population	D	1992	Derived, DIGESTYC, 1992
AG_M-male agricultural workers	%age of population	D	1992	Derived, DIGESTYC, 1992
INMIG_M-males migrating in	%age of population	D	1992	Derived, DIGESTYC, 1992
INMIG_F-females migrating in	%age of population	D	1992	Derived, DIGESTYC, 1992
Spatial data				
D_URB-distance to San Salvador	km.	M,D	2008	Derived, Centro Nacional de Registros
DUM_X-region	Code, Dummy variable	M,D	2008	Defined
AREA-total area	sq.km.	M,D	1992	DIGESTYC, 1992
Biophysical data (DEPENDENT)				
FOR_00-forest cover, 2000	sq.km.	M,D	2000	Hansen et al., 2006a
FOR_CHA-forest cover change, 2000 to 2005	sq. km.	M,D	00-05	Derived, Hansen et al., 2006a,b

**Scale: M=municipal
D=department

Data Preparation

Area estimates of forest cover change were aggregated from the 500-m MODIS tree cover estimates data product for 2000 and 2005 to municipal-level estimates of forest cover for 2000 and 2005. Area estimates of forest cover change were derived by subtracting the estimates of forest cover in 2000 from estimates of forest cover in 2005 (see Figure 5.2). From the tree cover data product, El Salvador is experiencing a net increase in forest cover.

Several steps were taken to prepare the census data for statistical analysis. Proportions of males and females working in agriculture and in-migrating were reported by the census at the department level only. For each municipality, AG_F, AG_M, INMIG_F, and INMIG_M represent the same proportion of the population as the department in which each municipality is contained. AG_EM and AG_M were logged to correct for skewness. Proximity, or distance (sq. km) to San Salvador (D_URB), was calculated using digital spatial data for each municipality from the Centro Nacional de Registros in El Salvador in a spatial analyst tool in ArcMap. A series of four dummy variables representing each of the four regions were generated using 1 to mark the "presence" of each municipality in the region of interest and 0 to mark the municipalities not in the region of interest.

Statistical Analyses

Statistical analyses, including classical hypothesis testing and multiple linear regressions, were carried out using Stata statistical software. For all tests, significance was calculated using p-value where: $p<0.001$ indicates significance at 99.9% confidence; $p<0.01$ indicates significance at 99% confidence; and $p<0.1$ indicates significance at 90% confidence.

For Hypothesis 1, forest cover change in El Salvador and in each region is tested for statistical significance in a two-tailed t-test, whereby μ equals the mean of forest cover change,

$$H_0\text{: } \mu_{\text{FOR\_CHA}} = 0\text{; and } H_1\text{: } \mu_{\text{FOR\_CHA}} \neq 0$$

For Hypothesis 2, I test whether there is a statistically significant difference between the means of male and female rates of formal participation in the agricultural sector in El Salvador, by department.

$$H_0: \mu_{\text{AG\_M}} = \mu_{\text{AG\_F}}; \text{ and } H_1: \mu_{\text{AG\_M}} \neq \mu_{\text{AG\_F}}$$

For Hypothesis 3, I test whether there is a statistically significant difference between the means of male and female rates of migration in El Salvador, by department.

$$H_0: \mu_{\text{INMIG\_M}} = \mu_{\text{INMIG\_F}}; \text{ and } H_1: \mu_{\text{INMIG\_M}} \neq \mu_{\text{INMIG\_F}}$$

Multiple linear regression analyses were carried out on the variables where forest cover change represents the dependent variable and select demographic and spatial variables represent the predictor or explanatory variables.

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k + \varepsilon$$

For Hypothesis 4 population density, sex ratio, gendered employment in agriculture, gendered migration, and proximity to urban areas correlate to forest cover change in El Salvador. Multiple linear regression was carried out on all variables (see Table 6.1) for El Salvador. Individual regression coefficients were tested for statistical significance using the t-test, measuring the contribution of an individual variable in the model.

$$H_0: \beta_j = 0; \text{ and } H_1: \beta_j \neq 0$$

An F statistic was calculated to test for the significance of the regression or for the analysis of variance, whereby:

$$H_0: \beta_1 = \beta_2 = \ldots = \beta_k = 0; \text{ and } H_1: \beta_j \neq 0 \text{ for at least one } j$$

The Variance Inflation Factor (VIF) was calculated to detect multicollinearity between the predictor variables or rather how much the variable of β_k is increased because of collinearity or high correlation among predictor variables. As a general rule a VIF > 5 indicates high multicollinearity.

A second multiple linear regression analysis was conducted with forest cover change as the dependent variable and only a selection of independent variables: population density, proportion population of female agricultural workers, proportion population of female immigrants, and proximity to San Salvador. The second analysis was conducted by excluding some predictor variables suspected of producing high multicollinearity.

For Hypothesis 5, the multiple linear regression analysis was carried out four additional times, where a dummy variable was used to represent each of the four regions to detect whether regional patterns in population density, sex ratio, gendered employment in agriculture, gendered migration, and proximity to urban areas correlate to forest cover change in each region. The VIF was calculated for each additional model.

IV. Results and Discussion

Forest cover change in El Salvador

The map in Figure 5.2 describes the pattern of forest cover change between 2000 and 2005 by municipality in El Salvador. Approximately 1% of the total land area reverted to forest; however, specific municipalities experienced much higher rates of forest recovery, while others experienced deforestation. Reforestation was primarily concentrated in the west and east of the capital, San Salvador, at approximate distances greater than 30 kilometers from the city center. Deforestation rates are generally greatest closest to the city center between 2000 and 2005.

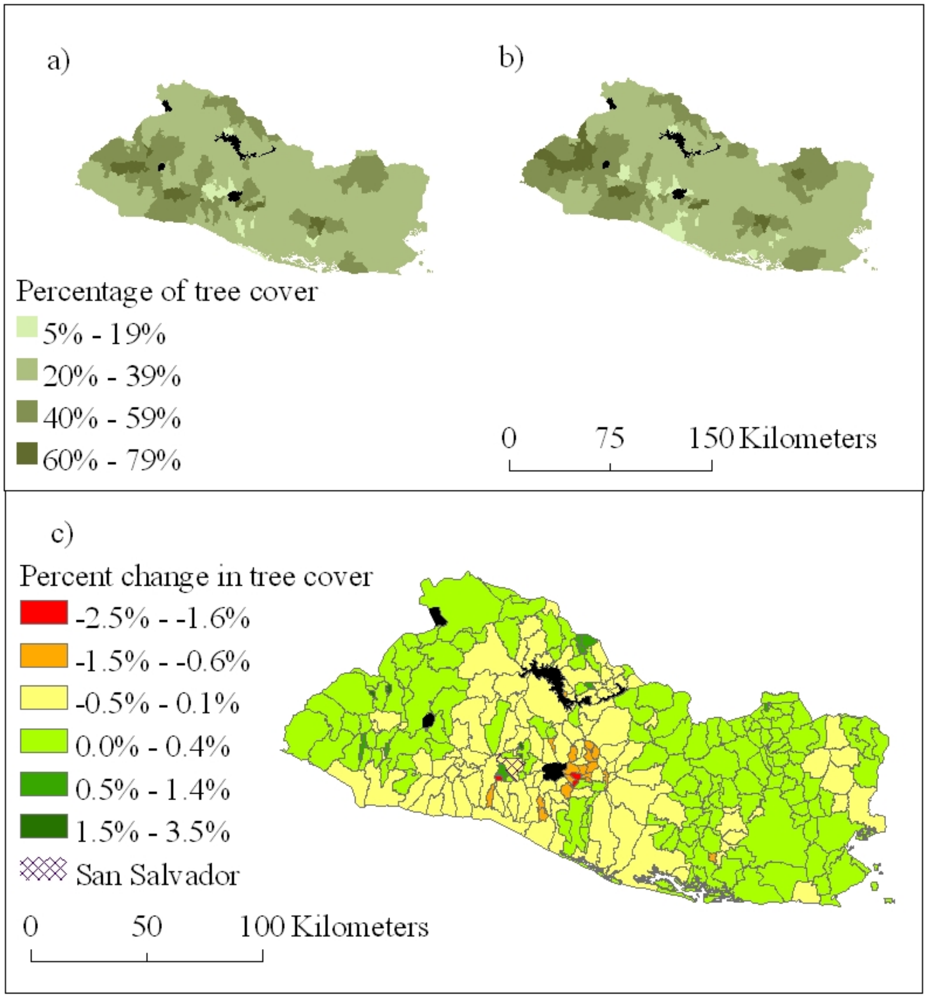

Figure 5.2. Tree cover change in El Salvador. (a) Percentage tree cover in El Salvador, by municipality, 2000; (b) Percentage tree cover in El Salvador by municipality, 2005; (c) Percentage change in tree cover, 2000-2005. Map by Jessica J. Kelly.

Box plot graphs (see Figure 5.3) illustrate the range of observations of forest cover change by region without reference to the possible drivers of forest cover change. The range of variation in Region 1 is considerably higher compared to the others; however, forest recovery is greatest here. The range of variation is lowered in Regions 2 and 4, but these areas also exhibit mostly positive forest cover change. Only Region 3, centered on San Salvador, exhibits negative growth with the least variation.

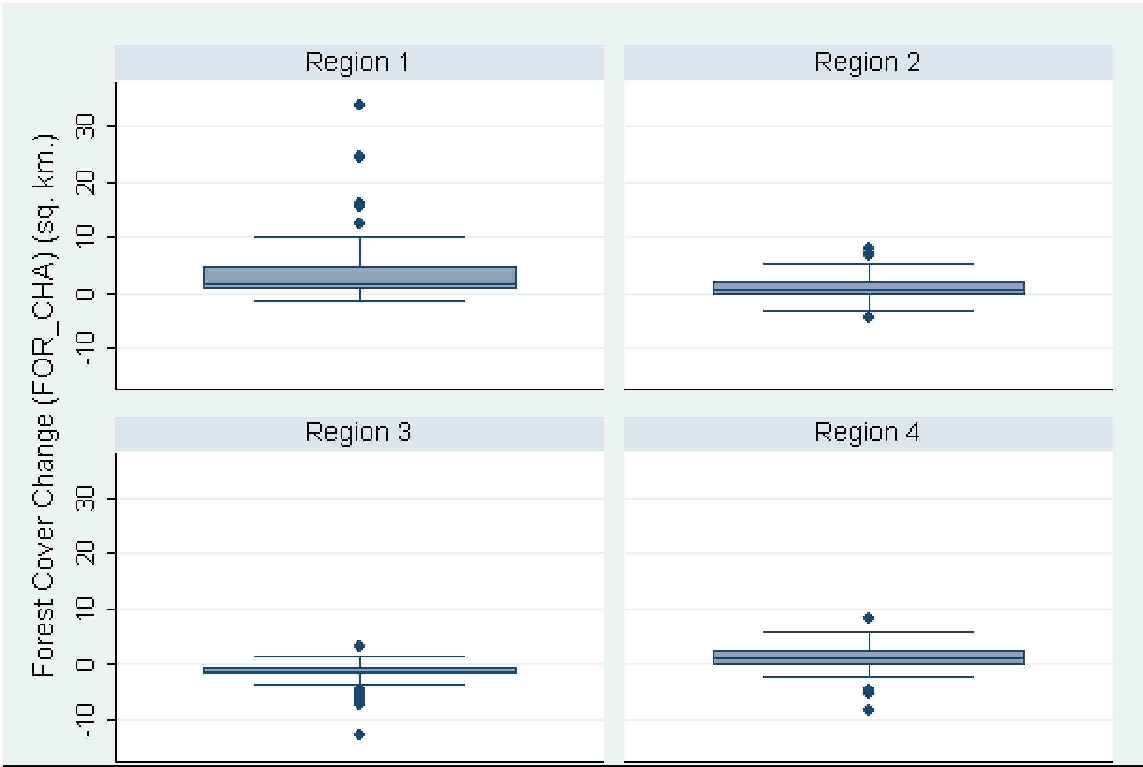

Figure 5.3. Box plots of forest cover change, 2000-2005, by region. Graphs by Jessica J. Kelly.

Classical hypothesis testing revealed that 1% forest cover change on the national scale from 2000-2005 was statistically significant in El Salvador (see Table 5.2), when the null hypothesis that the mean of forest cover change is equal to 0 could be rejected with 99% confidence. In fact, El Salvador is likely experiencing forest recovery and perhaps the last stage of forest transition. What is more interesting here though is that clear regional patterns of forest cover change exist, as the null hypotheses that the mean of forest cover change in each of the four regions equals zero was rejected. Region 1, with 99.9% confidence, is experiencing the most dramatic increases in forest recovery, however unlikely as out-migration and remittance incomes are lowest here. Not surprisingly, Region 3, with 99.9% confidence, continues to experience forest decline on average; while Regions 2 and 4 experience moderate forest recovery consistent with the national average. One key difference exists in the results. Region 4 is only significant at the 90% confidence level, leaving room for error in the interpretation of the meaning of forest recovery in a region well-known for ranching and logging operations.

Table 5.2. Hypothesis testing of forest cover change.

	El Salvador	Region 1	Region 2	Region 3	Region 4
Obs	261	38	86	89	48
Mean	0.75	5.41	0.92	-1.52	0.95
t-ratio	2.77**	4.10***	4.04***	-6.52***	2.25*
Decision[1]	Reject	Reject	Reject	Reject	Reject

1 * p < .10; **p < .01; ***p < .001

Having established that forest recovery is indeed occurring in El Salvador and that regional differences are significant, the exploration of possible drivers of forest cover change are now considered.

Drivers of forest cover change

Table 5.3 presents the descriptive statistics, including range, mean and standard deviation, for all of the variables in the analysis at the national level. Area and forest cover in the year 2000 are included to control for the physical differences and size between municipalities. Table 5.4 presents the descriptive statistics for select variables in the analysis at the regional level. In particular, these variables were chosen for their theoretically predicted importance in determining forest cover change as described earlier.

Table 5.3. Descriptive statistics for all municipalities.

Variable	Range Min.	Range Max.	Mean	SD
FOR_CHA (sq. km)	-12.89	33.87	0.75	4.36
FOR_00 (sq. km)	0.48	205.80	27.46	27.92
PDENS (pp/sq. km)	0.00	10645.37	400.26	1074.18
SEXRCO (M:F)	0.00	1.64	0.88	0.12
AG_EM (pp)	0.00	15081.00	2268.66	2211.67
AG_F (%)	0.18	1.04	0.65	0.23
AG_M (%)	2.25	21.11	14.35	5.05
INMIG_M (%)	1.74	12.35	4.89	3.28
INMIG_F (%)	1.77	14.86	5.51	4.25
D_URB (km)	0.00	158.77	64.35	1.09
AREA (sq. km)	5.40	668.38	80.52	86.45

Table 5.4. Descriptive statistics for select variables by region.

Region, obs	FOR_CHA (sq. km) **Mean** SD	PDENS (pp/sq. km) **Mean** SD	SEXRCO (M:F) **Mean** SD	AG_F (%) **Mean** SD	INMIG_F (%) **Mean** SD	D_URB (km) **Mean** SD
1	**5.41**	**292.97**	**0.89**	**0.87**	**4.03**	**60.26**
n = 38	8.14	285.71	0.07	0.08	1.91	12.36
2	**0.92**	**114.56**	**0.87**	**0.54**	**2.78**	**84.65**
n = 86	2.12	78.57	0.19	0.15	0.98	31.93
3	**-1.52**	**834.71**	**0.89**	**0.64**	**9.97**	**26.09**
n = 89	2.20	1749.32	0.07	0.30	4.38	12.23
4	**0.95**	**191.52**	**0.86**	**0.71**	**3.29**	**102.16**
n = 48	2.90	132.25	0.08	0.09	1.14	29.34

Since multicollinearity is likely among the sex-based variables for employment in agriculture and for in-migration, I tested for statistically significant differences in the means of AG_M and AG_F and INMIG_M and INMIG_F. It is likely that only one of each of these sets of variables will be employed in the final regression analyses. The results are presented in Table 5.5. With 99.9% confidence, male participation in agriculture is significantly higher than observed female participation in agriculture.

Though the results are not surprising, there are several reasons to consider that where female participation in agriculture is greater, forest recovery is likely greater; and where male participation in agriculture is greater, forest recovery is likely less. Since women more often participate in agricultural activities that are closer to home (i.e. house gardens and agro-forestry) and men more often participate in the types of activities associated with forest clearing (i.e. row cultivation, logging, ranching), both variables are likely to predict forest cover change in opposing ways.

A statistically significant result could not be derived from the comparison of means for sex-based differences in in-migration. Therefore, the null hypothesis that the mean of proportion of male in-migration equals the mean of proportion of female in-migration could not be rejected. The failure to reject the null hypothesis is related to the fewer number of observations. Since these variables were reported at the department level only, and not the municipal level, only 14 observations were employed.[16]

Table 5.5. Mean comparison for sex-based differences in agricultural employment and in-migration.

	H_0: $\mu_{\text{AG\_M}} = \mu_{\text{AG\_F}}$	H_0: $\mu_{\text{INMIG\_M}} = \mu_{\text{INMIG\_F}}$
Obs	14	14
Mean (M)	14.18	4.80
Mean (F)	0.67	5.46
Difference	13.51	-0.67
t-ratio	9.79***	-0.46
Decision[1]	Reject	Do Not Reject

1 * p < .10; **p < .01; ***p < .001

[16] In the multivariate regression analysis, the 14 values are extrapolated to the municipal level, creating 291 observations. While some distortion is created in extrapolating the 14 values at the department level to the municipal level, the distortion is unavoidable since data for employment data in agricultural and in-migration are reported at the department level only.

Explanations of forest cover change

Table 5.6 assesses the relative influence of the set of socioeconomic and spatial variables presented in Table 5.1 on forest cover change in El Salvador. As expected, multicollinearity was significant among the variables INMIG_F, INMIG_M, and AG_M, with variance inflation factors of 114.69, 95.73, and 6.80, respectively. With all others, multicollinearity does not appear to affect the results of the analysis.

Equation 1, despite the high multicollinearity among some variables, reveals some important results for the importance of sex ratio, gendered differences in migration and agricultural employment. Though the sex ratio (males: females) for individuals age 25-40 did not explain forest cover change with any statistical significance, the variable is relevant in theoretical discussion. As expected, the coefficient for SEXRCO is negative. That is, when men are present in greater numbers compared to women, forest cover change declines. This may be explained in the context of life cycle where men and women aged 25-40 are the most economically active. Recalling earlier discussions (see chapter 2), women of this age group are less likely to out-migrate from rural areas since more women in this age group have child care responsibilities compared to women aged 18-25 who emigrate at approximately the same rates as men in the same age group. This is especially important in rural areas where the sex ratio is closer to one.

This theory is further supported by the directionality of the coefficients for males and females employed in agriculture. When rates of male employment in agriculture increase, forest cover is expected to decline. However, when rates of female employment in agriculture increase, forest cover is expected to increase with a significance of 99.9% at the national scale. Finally, where high rates of male in-migration increase, forest also increases. The opposite is true for female in-migration, but can likely be explained by the fact that women are migrating at greater rates to urban areas where forest recovery is not taking place.

Table 5.6. Coefficients from regression of change in forest cover in El Salvador, 2000-2005.

	Equation 1 (All Variables)		Equation 2 (Select Variables)	
	Coefficient [1] (t-ratio)	VIF	Coefficient [1] (t-ratio)	VIF
FOR_00 (sq. km)	.0646*** (6.12)	1.72	0.0670*** (6.34)	1.69
PDENS (pp/sq. km)	0.0008*** (-2.78)	1.68	.0008*** (3.32)	1.39
SEXRCO (M:F)	-1.17 (-0.6)	1.13		
AG_EM (pp)	1.73 (1.57)	1.51		
AG_F (%)	338.85*** (3.08)	1.25	332.19*** (3.06)	1.19
AG_M (%)	-8.07 (-0.69)	6.80		
INMIG_M (%)	37.37 (0.66)	95.73		
INMIG_F (%)	-98.27 (-1.46)	114.69	-34.43*** (-4.46)	2.09
D_URB (km.)	0.0052 (0.51)	3.03	.0058 (.71)	1.87
AREA (sq. km)	-0.0024 (-0.70)	1.75	-0.0033 -0.98	1.67
R^2	.3348		.3110	
Adjusted R^2	.3081		.2947	
N	261		261	
VIF		22.93		1.65

1 * $p < .10$; **$p < .01$; ***$p < .001$

Population density (see Figure 5.4) is positive and significant in Equation 1; however, the magnitude by which forest cover change is explained by population density is low (coefficient = 0.0008). The result is important though when considering that places with the greatest population density (or the outliers like San Salvador) experienced negative forest cover change. A positive relationship between population density and forest cover change is somewhat surprising, but it suggests that El Salvador may not fit the typical Latin American case study of forest cover change in the tropics.

Equation 2, tests the explanatory power of population density, proportion of women employed in agriculture, proportion of women in-migrating, and proximity to San Salvador in predicting forest cover change. Similar to Equation 1, PDENS and AG_F are positive and significant with 99.9% confidence, and now INMIG_F is negative and significant with 99.9% confidence at the national level. The regression analysis is significant for explaining forest cover change with an R^2 of 0.3110. However, D_URB is not significant in predicting forest cover change at the national scale.

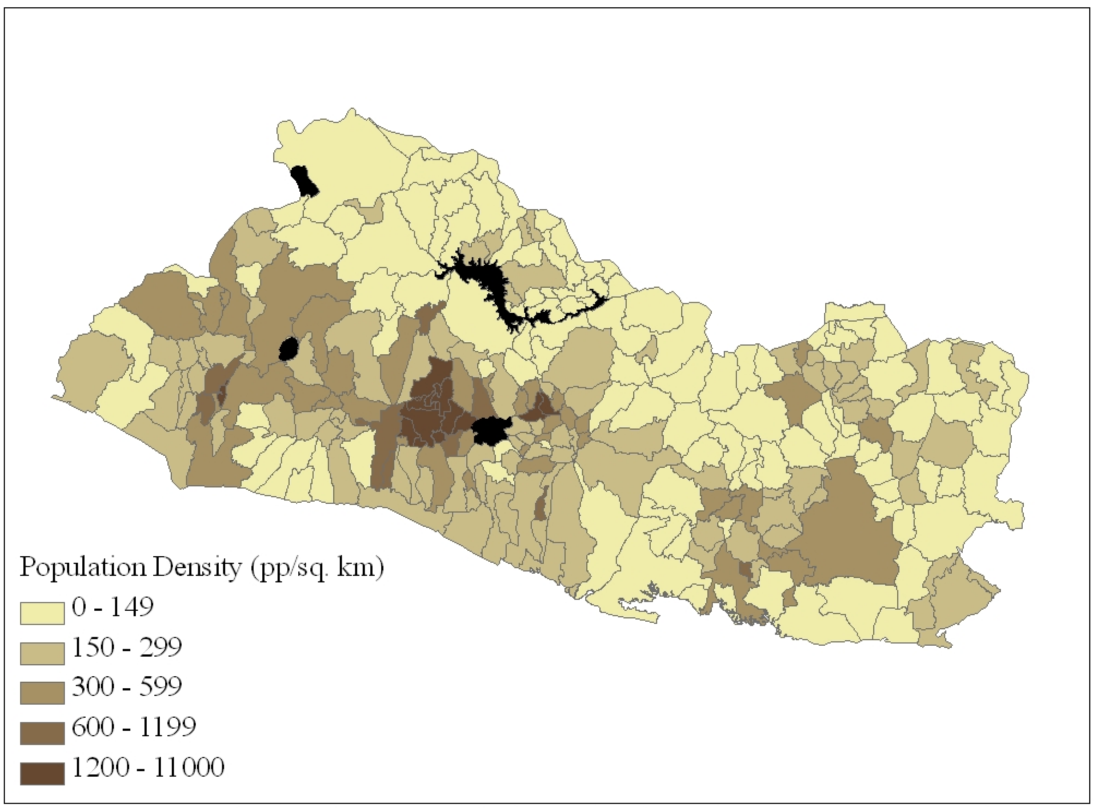

Figure 5.4. Population density by municipality and region, El Salvador, 1992. Map by Jessica J. Kelly.

Regional explanations of forest cover change

By incorporating generalized regional characteristics using the dummy variables (DUM_1, DUM_2, DUM_3, and DUM_4), results indicate that regions do have an important effect in predicting forest cover change (see Table 5.7). Below, I discuss how forest cover change is influenced by the same set of predictor variables as Equation 2 in conjunction with the observed regional characteristics within El Salvador. The results have important ramifications for the path by which forest transition occurs in El Salvador.

In Equation 3, Region 1 is the dummy variable. Population density continues to be a positive and significant predictor of forest cover change. Remembering that Region 1 exhibited the highest of all rates for forest recovery from 2000-2005, population density was also significantly higher in this region compared to the less densely population regions in the north and east. Region 1 also had more secure forms of land tenure compared to the northern region. Furthermore, in-migration by women has a negative and somewhat significant (90% confidence) effect on predicting forest cover change, and the proportion of women in agriculture is not statistically significant in explaining forest change. What this suggests is that the gender dynamic is not important in Region 1 on a macro-level. This is expected since out-migration is significantly lower, the impact from the civil war was minimal and sex ratios are closer to one compared to Regions 2 and 4. In addition, proximity to San Salvador was positive and significant here in predicting forest cover change. That is, as distance increased from the urban center, forest recovery became more robust. The linear regression, where DUM_1 was included, was statistically significant with 99.9% confidence and an R^2 of 0.4018. Region 1 appears to follow the forest scarcity path in that agricultural lands are not being abandoned, but forests are intentionally being restored. The pattern is more characteristic of the patterns observed in Africa and Asia, rather than in Latin America (Rudel 2005).

Table 5.7. Coefficients from regression of change in forest cover by region, 2000-2005.

Variable	Equation 3 Region 1 Coefficient [1] (t-ratio)	Equation 4 Region 2 Coefficient [1] (t-ratio)	Equation 5 Region 3 Coefficient [1] (t-ratio)	Equation 6 Region 4 Coefficient [1] (t-ratio)
FOR_00 (sq. km)	.0585*** (5.87)	.0671*** (6.33)	.0650*** (6.17)	.0655*** (6.26)
PDENS (pp/sq. km)	.00526*** (2.21)	.0008** (3.18)	.0008** (3.11)	.0008*** (3.54)
AG_F (%)	26.13 (.23)	304.89** (2.55)	320.80** (2.97)	363.36** (3.37)
INMIG_F (%)	-10.09* (-2.36)	-35.39*** (-4.47)	-23.33* (-2.58)	-33.18*** (7.64)
D_URB (km.)	.0193*** (2.45)	.0066** (3.18)	-.003 (-.33)	.0153* (1.75)
AREA (sq. km)	-0.0032 (-1.01)	-.0035 (-1.02)	-.00349 (-1.04)	-.0022 (-.65)
DUM_1	4.37*** (6.20)			
DUM_2		-.3365 (-.56)		
DUM_3			-1.88* (-2.30)	
DUM_4				-1.81** (-2.72)
F (7, 253)	24.28***	16.38***	17.41***	17.85***
R^2	.4018	.3118	.3251	.3305
Adjusted R^2	.3853	.2928	.3064	.3120
N	261	261	261	261
VIF	1.73	1.70	2.02	1.66

1 * p < .10; **p < .01; ***p < .001

Equations 4 and 6 include the dummy variable for Regions 2 and 4 respectively, or the northern and eastern portion of the country. In this case, each of the variables of interest provides explanatory power for forest cover change. PDENS, AG_F, and D_URB are positive and significant, suggesting now that these regions differ from Region 1 in that gender now matters. This is consistent with the expectation that gender plays a more important role here because: (1) both of these regions were negatively affected by the civil war; (2) out-migration (and human losses by war) of men was significant during the 1970s and 1980s; (3) remittances are greater here compared to other areas of the country; and (4) land tenure is least secure in Region 2.

Now gender matters (as in AG_F) for forest cover change, but not in the way expected. Since land tenure is less secure in Region 2, I would have expected that women would be more likely to engage in forest clearing to establish ownership over land. Rather it would seem that as women are more likely to be engaged in agriculture, they are more likely to be allowing forest recovery in the forms of agro-forestry and woodlots near their homes. Thus if the forest recovery in Region 2 is taking the agro-forestry form, it is possible that women may be strengthening their claims to land by demonstrating active use. Women in-migrating in Region 2 are often women who had fled during the civil war across the border and into Honduras (Reyes 2007). These women are least likely to have secure claims to land compared to women in other parts of the country. This may be reflected in the overall increase in the magnitude of the coefficient for (INMIG_F) for this region compared to the others, indicating that at least in part, land tenure does matter. In Region 4, women engaged in agriculture is perhaps most significant here. Since the region is marked logging and ranching activities, an increase in the proportion of women in agriculture is more likely to have a greater impact on positive forest cover change. The economic development path may have some importance in Region 4 since out-migration and remittances are high in the area.

Finally, Equation 4 includes the dummy variable for Region 3 (metropolitan San Salvador and surrounding areas). Because forest cover is declining on average and peri-urban land uses dominate, we expect that gender matters in so much that women in agriculture near San Salvador are likely to hold land securely and when they are more often engaged in agriculture, forest recovery is greater. Overall, the proportion of women engaged in agriculture has the greatest explanatory power for determining forest cover change. However, the case for the significance of the gender dynamic (particularly in the western region) is not fully captured by the regional analysis.

The case study of Cantón El Tigre (see chapter 6) allows for an examination of the impacts of gender, land tenure, and migration as they relate to forest cover change at the local level. The community has experienced forest recovery, though forest cover can be characterized as primarily early succession, scrub growth, orchards, backyard woodlots, and living fences. In this sense, El Tigre exhibits the characteristics of having just reaching a turning point. However, with very little out-migration, an exploration into the factors that encourage or discourage forest recovery should help to describe the gendered nature of the relationships between these factors that promise to shed new light on the forces that drive forest transitions.

Chapter VI: Household Strategies for Land Use in Cantón El Tigre, El Salvador

> El Tigre may go hungry…these days people are selling jocote[17] in order to be have something to eat…(Moreno 2002).

Introduction

The 2002 newspaper headline, reproduced above, was designed to call attention to the desperate conditions facing rural people in Cantón El Tigre. While the circumstances of poverty facing the farmers here were not necessarily unique to rural El Salvador, what they were doing to overcome food shortages was then and is now an increasingly important strategy for the household. The shift is significant for environmental change in El Salvador. For some, backyard woodlots and orchards are supplementing the more traditional row cultivation in this small community that by the 1980s had been nearly completely deforested. Tree cover is increasing here (Cuellar 2005). With increases of agricultural activity in favor of agro-forestry, this particular case may signal a forest transition that more closely resembles the characteristics of the forest scarcity path of the forest transition theory (see chapter 2).

The Cooperativa El Tigre, a reform cooperative created from Phase I of the agrarian reform, allowed for existing residents of a large hacienda to have access and rights to land. Others in the community came to occupy land after Phase III of the agrarian reform. Phase III, the land-to-the-tiller program, granted "legal" ownership rights to those working plots of less than 7 hectares. However, few residents have formal title to the land they currently occupy. In general, land tenure is considered relatively

[17] Jocote, also known as Purple Mombin (*Spondias purpurea)*, is a small deciduous tree with edible fruit that are similar to small plums in appearance and flavor. The trees reach 9-m in height.

secure in western El Salvador compared to other rural areas of the country. In addition, men and women participate in the cooperative and in different types of agriculture at different rates. In this chapter, I explore the implications of these differences for land use and forest cover on the local scale, and I discuss the significance of this case for a gendered explanation of forest transition in El Salvador.

I. Considerations for Social Capital and Ethnography in Land Use Change in Cantón El Tigre, El Salvador

Theorists of social capital posit that social networks have value, and the value of social networks may result in positive or negative outcomes for the community. Recent studies suggest that, at the regional level, secure land tenure in cooperative communities may contribute to improved forest conservation since in-migration is slowed and agricultural extensification is reduced (Carr and Barbieri 2006). However, studies of forest cover change and coffee cooperatives in El Salvador demonstrate that some cooperatives have had a negligible to negative impact on tree density and diversity, since collective management produced conflict (i.e. uncertainty or division over the allocation of responsibility for care of trees and distribution of tree products grown on collectively managed lands), resulting in pressures to maintain shade trees specific to coffee-growing only (Mendez, Gliessman, and Gilbert 2007). The implications for forest cover change with respect to reform cooperatives, such as the one in El Tigre (not shade-grown coffee cooperatives), are thus not clear and warrant further investigation.

The concept of social capital is rooted in sociological understanding of social networks, and several definitions of social capital are useful for the purposes described here. Putnam describes social capital as the "features of social organization, such as networks, norms and social trust that facilitate coordination and cooperation for mutual benefit" (Putnam 1995). The strongest example of social organization in El Tigre is in the form of Cooperativa El Tigre, a democratically managed group. Norms have been established in what lands are used for cultivation (productive lands located at the outskirts of the main settlement area), what lands are used for residences (a core area of small household plots), and what land uses are appropriate (i.e. agro-forestry, animal husbandry, row cultivation, etc.) and by whom in each of those spaces. As such, the cooperative may influence household decision-making.

Those norms include a gendered component which have been observed elsewhere (Fortmann and Bruce 1988; Rocheleau and Edmunds 1997; Schroeder 1998). In their work in the Dominican Republic, Rocheleau and others found that women faced challenges in benefiting from forest productivity in ways similar to near-landless families, since male headed households owned and managed by men resulted in women's lack of power or land tenure insecurity within the household (Rocheleau et al. 2001). Forests in El Tigre are, as they are in other places, marked by gendered social relations within the household. Though important, land tenure security issues are primarily explored between households, rather than within them.[18]

Social trust is established among the cooperative's members to allow for enforcement of rights and responsibilities between households, as well as opportunities

[18] The rationale for the choice to focus on the head of household, as an interview strategy, is justified by the suspicion raised by exploring household dynamics in the short-time devoted to conducting interviews. In several instances, interviews were conducted with several members of the household simultaneously. However, the small sample size of non-heads of household females would not yield reliable results. Rather, qualitative data from these instances were used in several instances to discuss intra-household dynamics.

for improving the village as a whole. In this way, the social capital and the norms associated with it have a function. For Coleman:

> Social capital is defined by its function. It is not a single entity but a variety of different entities, with two elements in common: they all consist of some aspect of social structures, and they facilitate certain actions of actors – whether persons or corporate actors – within the structure. Like other forms of capital, social capital is productive, making possible the achievement of certain ends that in its absence would not be possible (Coleman 1988).

The cooperative and the social capital it perpetuates in El Tigre are likely to have important ramifications for land use decisions and corresponding tree cover. Capturing the significance of an abstract driver of land use change, like social capital or social organization, is not an easy task. I attempt to explore its relevance via ethnography.

While ethnography is defined as a methodology, the technique ranges considerably from study to study. However, all ethnography rests on a critical set of minimum criteria. Ethnography, at a minimum, is iterative-inductive research that evolves throughout the study, draws on multiple methods (including watching, listening, and inquiring), involves direct and sustained contact with people in the context of their daily lives, and producing a rich account that respects the human experience. Ethnography also acknowledges the role of theory, the role of the researcher, and the role of the relationship between researcher and subject (O'Reilly 2005). For some, time is also a criterion, or rather a minimum of one to two years in the community (Atkinson et al. 2001).

II. Hypotheses

Considering the potential explanatory power of gender and social capital in the cooperative structure, I examine the relationship between them and several variables of interest. The variables of interest include perceptions of forest cover change, benefits or value of tree/tree-planting, perceptions of threats of land invasion or encroachment, experiences with threats of land invasion, participation in agricultural activities, receipt of remittances, and observations of tree cover increase.

The following hypotheses are tested using simple statistical methods and evidence from interviews: (1) men are more often members of the reform cooperative than women; (2) perceptions of historic forest cover change in El Tigre are equal among men and women and among members and non-members of the cooperative; (3) benefits of forests are perceived equally by men and women and by members and non-members of the cooperative; (4) perceptions of risk of land invasion and encroachment are experienced differently by men and women and by members and non-members of the cooperative; (5) histories of land-takings are reported at significantly different frequencies by men and women and by members and non-members of the cooperative; (6) economic activities in agriculture are different by men and women and by members and non-members of the cooperative; (7) remittances are sent equally to households headed by men and women and by members and non-members of the cooperative; and (8) increase in tree cover depends on whether households are headed by men or women and by members or non-members of the cooperative.

III. Methodology

Study Area and Background

Households were selected from Cantón El Tigre, because of the cantón's relative proximity to the El Imposible and Montecristo National Parks and the proposed

Mesoamerican Biological Corridor projects (see Figure 6.1) that would connect the parks in a direct route to other parks from Mexico to Colombia. Households in Cantón El Tigre also exhibit demographic characteristics typical of the western region of El Salvador.

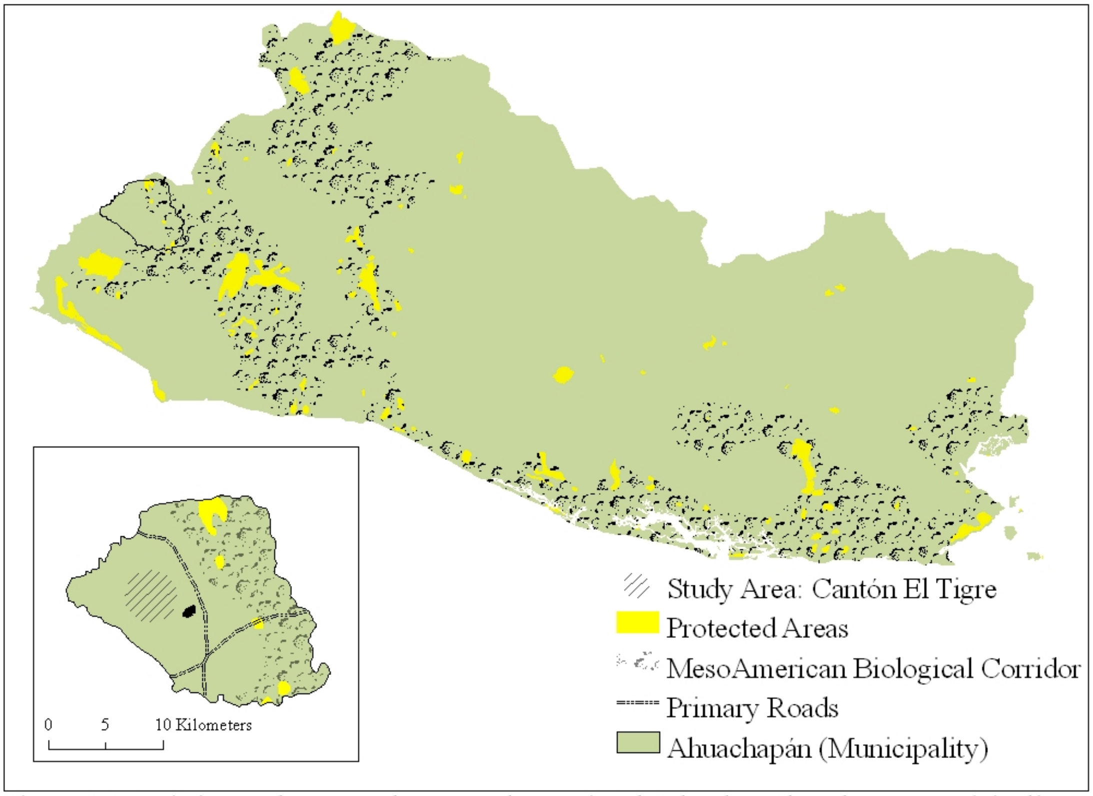

Figure 6.1. Existing and proposed protected areas in El Salvador, Ahuachapán municipality, and Cantón El Tigre. Map by Jessica J. Kelly.

Cantón El Tigre (see Figure 6.1), located in the department of Ahuachapán, is a small community near the border of Guatemala along el Rio Paz. Twelve kilometers of a seasonal road connects the tiny community of approximately 650 families to the nearby city of Ahuachapán. In many ways, this place differs significantly from productive areas in Santa Ana and in the eastern departments like La Unión (Reyes 2007). Agricultural productivity is notoriously difficult in El Tigre as soils have been overburdened by year-to-year cultivation, but everyone in the community is engaged in agriculture, at least in part, and forests are said to be increasing here (Kelly, field notes). Prior to 1990, the village was completely deforested. The area is frequently affected by El Nino, causing drought for sometimes up to 18 months at a time (Moreno 2002).

The residents of Cantón El Tigre have a long history of presence on the landscape since the land was formerly controlled by one owner or patron (Gonzales 2007). Many of the current residents are the former resident workers of the patron or descents of those workers, though there have been some residents who moved to the village after the village was expropriated and converted, in part, to a cooperative, Cooperativa El Tigre, where resident workers were granted access right and use rights to cooperative lands. According to a key informant, the area was primarily cultivated with rice under the patron (Kelly, field notes). Little in-migration or out-migration has occurred in the community. The rural farming families of the study area are poor, with few opportunities for wage labor outside of agriculture, and households engage in a mix of subsistence and limited commercial farming.

Land is organized according to use. Members of the cooperative live on small household plots where backyard orchards and gardens are fairly common. Lands for row cultivation are located some distance away (average 3 km) from the land designated for homes (in the areas surrounding the core settlement area). Row cultivation is concentrated on the best lands for production. The dominant crops are beans, corn, and a type of sorghum, maicillo, on property managed by the cooperative (Kelly, field notes). On individual or household plots, members of the cooperative participate in animal husbandry and grow a diversity of crops including yucca, pipian, and jocote. On household plots not part of the cooperative, residents are more likely to cultivate grain crops adjacent to the household plot or may rent land further from the home (Gonzales 2007).

When established, the cooperative was dominated by men as a direct result of the agrarian reform that dictated that the workers in the field represent the household in the communal land system of tenure. In recent years, however, women have enjoyed a more participatory role in decision-making within the cooperative. All land, including the land under row cultivation at the outskirts of the main settlement area and the household plots at the core settlement area, are held by the cooperative whereby members participate in collective decision-making regarding cultivated lands. Members have greater autonomy over individual household plots via usufruct rights; however, these lands may still be subject to oversight within the cooperative.

As fruit trees are becoming a more important source of supplemental income and for household consumption, more residents of El Tigre are planting fruit trees in backyard woodlots and orchards. Some of the most common species observed in El Tigre included: jocote, mango,[19] maranyon,[20] lime,[21] sapote,[22] ice cream bean,[23] and chaparro.[24] Given these patterns, the focus of the study is centered on household plots, ignoring lands designated for row cultivation.

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[19] *Mangifera indica*, an evergreen tree, reaches up to 30 meters.

[20] Cashew nut, *Anacardium occidentale*, an evergreen bearing fruit at a young age, reaches up to 10 meters. It is successful in areas with hot, dry seasons.

[21] *Citrus aurantifolia* reaches up to 6 meters.

[22] *Pouteria sapota* is one the best known native trees in the region that produces large edible fruit. Its wood is also used in carpentry. Trees reach up to 30 meters.

[23] *Inga edulis* is common in coffee plantations because it is a fast-growing tree used to provide shade. Its seed pods contain a sweet white pulp that tastes like vanilla ice cream. The tree reaches heights of 12 meters.

[24] *Curatella Americana* is a small tree used for fuel, charcoal, fence posts, and furniture.

Data Sources and Data Collection

Interviews were conducted to produce data about households and land use and to improve upon the methods for land cover classification in the remote sensing analysis portion of the research (see chapter 4). In 2005 and 2007,[25] I conducted key informant interviews, semi-structured interviews with heads of household, group interviews, and other unplanned informal meetings with approximately 50 residents of Cantón El Tigre and several representatives of non-governmental organizations involved in women's development issues and reproductive health and government workers associated with various projects in El Tigre. In addition, I spent considerable time observing women in their various roles and responsibilities in daily living.

Using an area probability sample, I selected 40 households in El Tigre. The area probability sample allowed for probabilistic variation in independent variables: gender of household head, number of household members, occupations, and income sources. Since most of the interviews were conducted by traveling on foot to reach many of the subjects, time was maximized by taking samples from three clusters within El Tigre. As roads were frequently impassable by motorized vehicle, I walked to all of the participants' homes, within an approximate 3.5-km radius.

Key informants were selected on the bases of recommendations from researchers and NGO and government workers already familiar with community leaders in El Tigre. Also, key informants were identified from the recommendations of participants in

[25] Interviews were completed over the course of four months. Still, the study may still be loosely considered ethnography for the minimum criteria it does meet. I appreciate that my account may not be as rich as it could have been had more time been spent in El Tigre. In addition, my intention to quantify some of my results has resulted in a mixed method that may be described as an impure ethnography since surveys were employed to obtain quantitative data. The result may be an untraditional ethnography, but one that is still deeply respectful of the human experience and open to inductive forms of inquiry.

household interviews. Key informants included both men and women, long-time residents of El Tigre, and community officials, representatives, and advocates. While interviews with heads of household followed a structured, tested set of questions, key informant interviews were unique to the individual as each offered detailed understandings about specific topics. Key informant interviews tended to be less structured, and frequently, key informants led the conversations in several directions that could not have been planned for. These tangents were tremendously helpful in providing contextual understanding of the relationship between women and forest cover change in El Salvador. Key informant interviews were held for 120-165 minutes.

The methods employed raised ethical questions both before and during the time the research was carried out in El Tigre. Early on, my overriding concern was in the reliability of the accounts provided to me during the interviews, since I was unsure how well I would be accepted in the community as a gringa, or whether participants would be willing to share information about the status of land title or money received from abroad, as the information may be considered private or may draw attention from the authorities if participants didn't trust what I was to do with the information. However, my first responsibility was and is always to the research participants. As such, I conducted the research with the aim of maintaining complete transparency about my purposes in El Tigre.

In El Tigre, I held nearly all household interviews on the verandas of subject participants' homes, arranged in advance with the assistance of Amanda Gonzales, a midwife from El Tigre and a member of Cooperativa El Tigre. Gonzales was known by the residents and was trusted as someone who cared for them, and she accompanied me during my visits to the participants' homes. Subjects were informed in advance of the purpose of the study, the types of questions posed during the interview, and the ways in which the data would be used. Participants were asked to sign an informed consent form, approved by the Rutgers University Institutional Review Board. All participants were encouraged, at the first moment of discomfort, to refuse to answer questions or withdraw from the interview at any time. With the aid of interpreter and research assistant Erika Lopez, I was able to maximize the validity and reliability of my interpretation of meaning conveyed during the interviews and in the interpretation of the results. I understood basic conversational Spanish, but I was not fluent in Spanish.

Interviews began with an informal discussion to help ease any discomfort between the participant and my team that may have initially been created by the formality of the informed consent process. The first part of the interview asked participants to provide an oral history of land use and forest cover on their own property. In the second phase of the interview, I used a semi-structured interview schedule to obtain specific data about the variables under investigation (see Appendix A). Lastly, participants were asked to conduct walking tours of their property with me or sketch a detailed map of their property[26].

Despite my best attempts to allay the concerns or doubts of my research subjects, my sudden interest in this small community that generally receives little attention with regard to environmental projects sparked some early suspicion by a few men in the community. In two instances after subjects agreed to be interviewed, participants

[26] On the walking tour, I collected ground control points with a GPS device, a Garmin eTrex Legend, and sketched land cover maps for improving the accuracy of classification in the image analysis (see chapter 5). (Kwan 2002; Sharp 2005).

questioned whether my research was really about reforestation in El Tigre. In one case, a male resident of El Tigre made accusations:

> You're lying about your purpose here. If you were interested in forests in El Tigre, you would not ask questions about money or about my title. You are working for someone. (Male resident, J. Kelly, field notes)

I responded by explaining again why I was interested in asking the types of questions posed, reiterating where I was from and why I was conducting the study, but still, I politely stopped my questions, ended the interview, and informed the participant that I would not use his earlier responses. Sensing my discomfort, the participant once again granted permission to use his information. I have, however, chosen to exclude the data on the grounds that the data may not be as reliable. In a second instance, a man permitted an interview, but in the end, he did not want me to use his information for fear that the information would be used by someone else to evict him from his property. While there were many in the community who did not have official documents or were behind in payments, no others expressed to me or to others the same level of concern about my intentions or purposes in El Tigre. Still, the concern is a valid one that I take very seriously. I have chosen to aggregate data and to maintain the confidentiality of those individuals who I quote, despite participants' permission to allow me to use their names.

Data Preparation

In the data analysis, I coded interviews according to quantitative or qualitative data. Quantitative data included interval data: numbers of years in residence, ownership in livestock, numbers of household members who have out-migrated, value of remittances, head of household age, number of individuals living in the household, number of income earners in the household, and level of schooling; and categorical data: status of residence (rent/own/squatting), status of legal documentation (titled/untitled), membership in cooperative, types of crops cultivated, the status of that migration (permanent/seasonal), destinations of migrants, significant household economic activities, head of household sex. Qualitative data centered on perceptions of changes in land use and forest/tree cover, ability to acquire land and land title, benefits of forest recovery, reliability of authorities to enforce laws regarding access to land. Finally, participants were asked to rank their level of fear about the threat of eviction or encroachment on occupied land. In this sense, perceptions were quantified.

Data Analysis

Data analysis included descriptive statistics, with particular interest in mean and standard deviations of demographic information for the sample. Answers to questions in interviews were cross tabulated according to membership in the cooperative and sex. Statistical significance was assessed using the chi square test. Stata statistical software was implemented to conduct the analysis. In addition, responses from interviews were grouped and used to illustrate similarities in responses.

IV. Results and Discussion

Men and Women in the Cooperative: Description of Sample

The demographic characteristics observed in the sample are consistent with expectations for the western region (Region 1) of El Salvador and the overall national statistics[27] of household and community composition regarding demographic characteristics (see Table 6.1).

Table 6.1. Demographic characteristics of the sample from Cantón El Tigre.

Percentage of Households Headed by a Female	Mean age of Head of Household	Mean Number of In-Residence Members per Household	Mean Number of Wage Earners per Household	Mean of Household Head's Highest Level of Schooling	Mean Number of Yrs in Residence
30%	48.8	6	2.6	3	22.7

n = 40
Source: J. Kelly, field notes

The percentage of female headed households is approximately one-third of total population, consistent with predictions. This observation similar to other findings in that in 2007, 34 percent of Salvadoran families nationwide were headed by women (CEDAW 2007). The number is slightly lower than that of northern or eastern regions (Oriental, and departments: Chalatenango and Cabanas) of El Salvador that were more heavily affected by the civil war. The western region of El Salvador was less affected by the civil war and experienced less out-migration.

The mean number of years in residence across all households suggests that the average household established residence in the community around the time of Phase I of the agrarian reform in the mid-1980s. For some that are above the mean, the head of household generally had a direct relationship or was himself a resident worker of the former patron. For all long-term residents, the heads of household were members of the cooperative. More recent residents are those less likely to be associated with the cooperative.

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[27] Compared to data from DIGESTYC (see Chapter 6).

Cooperative membership varies on the basis of sex of head of household (see Table 6.2). Consistent with the findings of Mendez and others, men are more likely than women to claim membership in a reform cooperative (2007). This is largely expected based on how land ownership was defined under Phase I of the agrarian reform.

Table 6.2. Cross tabulation and Chi-square for members of cooperative by sex.

	Male	Female
Member	16	1
Non-Member	12	11
Pearson X^2, $df(1) = 8.189$, $p < 0.004$		

History and Value of Tree/Forest Cover

Cantón El Tigre is historically characteristic of the popular imaginings of the landscape of El Salvador—completely deforested, under heavy cultivation, and too many people. Today, that landscape is changing, with increases in forest cover according to several sources (Cuellar 2005; Gonzales 2007; Hecht and Saatchi 2007; Reyes 2007).[28] According to one elderly resident, the change is positive:

> When I first arrived here when I was very young, the land was desolate with no trees anywhere, and it had small hills where the milpa was grown. A house was given to me with this land because I lived as a squatter back then. Later on, I continued taking care of the land by planting seeds and trees. At the time, there was a patron, and he had given a small piece of land to work for myself and my family. As I continued to work on the land and I did well, more land was given to me. When the decree was made, the patron sold the land to a financier, and he requested that the property should be divided to the people who already lived here and worked here or have an organization in charge of the land. The change gave us the opportunity to work on the lands we lived on. Land was given to me because of the reform. Each person took the land that they worked on as I did, in

> which he gave me three or four manzanas[29] of land. We continued working on the soil that was not damaged but only neglected. Caritas[30] came here to help show us how to take care of the land. They brought tools and material to work on the land. Now the soil has improved and it has a lot of plants, trees, and good harvests. (Elderly male resident of Cantón El Tigre; Source: J. Kelly, field notes).

Eighty percent of those residents interviewed observed that the landscape was changing for the better,[31] with increases in orchards, living fences, scrub group, and early successional forests (see Table 6.3). However, not all residents find that the changes are positive. Of those interviewed, 20% observed that forests were being cut more often in recent years and viewed overall changes in land use negatively. While representing only a small percentage of those interviewed, what is interesting is that of those 20% who observed negative changes, 37.5% were women, but more significantly, 87.5% of those negative observations were not members of the cooperative, suggesting several possible explanations.

Table 6.3. Cross tabulation and Chi-square for perception of tree cover change, 1987-2007.

	Male	Female
Increase	23	9
Decrease	5	3
Pearson X^2, $df(1) = .2679$, $p < 0.605$		
	Member	Non-Member
Increase	16	16
Decrease	1	7
Pearson X^2, $df(1) = 3.6829$, $p < 0.055$		

[29] One mazana equals approximately 1.7 acres.
[30] Caritas Internationalis is a Catholic humanitarian aid organization with programs in rural development and environmental management in over 300 communities in El Salvador.
[31] Residents were asked to describe land use changes over the previous 20 years, to make an assessment as to whether those changes were positive or negative, and to explain why they viewed those changes as better or worse.

A difference in time of settlement might explain the apparent discrepancy in that long-time residents (and cooperative members) are more likely to remember nearly complete deforestation from more than twenty years ago, and presently recognize the planting of trees for fuel wood and fruit and the abandonment of less productive fields with new scrub growth as increase in tree cover. Meanwhile, more recent residents (more often, non-members who have settled within the last twenty years) recall areas of extensive tree cover which are being cut today for fuel wood.

> The land has changed completely because when I was little I remembered how beautiful it was with the trees. Now it is horrible how the trees are being cut down. The people of El Tigre are cutting down trees for wood and not replanting new ones. (Young female resident of Cantón El Tigre; Source: J. Kelly, field notes).

Another resident recalled how 30 years earlier, there was heavier forest cover on the mountainsides not far from El Tigre on the east side of the major road that connects El Tigre to Guatemala and the city of Ahuachapán. Today, he calls El Tigre a "semi-desert" since the climate is getting hotter, the soils are getting drier, and trees struggle to grow (Kelly, field notes). He also discussed the problems of misunderstandings about the importance of forests to the community, and that the result was a failure to practice replanting after clear-cutting.

These apparent contradictions represent two trends that are underway in El Tigre. One is that some forests are being cut for fuel wood. These forests tend to be in areas where people are not living or cultivating crops. The fuel wood is collected from steeper slopes and in areas with poorer soils. The second trend is that forest cover is increasing in areas nearer to peoples' homes for the benefits of shade, fruit, and as barriers between properties as living fences. One woman accounts for the increase in tree-planting nearer to homes.

> It was unlivable and nothing was alive on this land. When I first came here I was really young but since that age and having kids, we were able to plant trees to improve the land in order to have some fruits. (Elderly female resident of Cantón El Tigre; Source: J. Kelly, field notes)

Different forests have different values, then, and different uses by different users. Accordingly, residents overwhelming report that species near their home are valuable for fruit, shade, and barriers between their properties, but most often, species further away from their homes represent a source of fuel wood. The pattern is consistent with the expectation that land receiving more frequent visits is located closer to the road and to the household.

The perceived benefits of increasing tree cover are significant in understanding possible forest cover change in El Tigre in light of forest transition theory. Based on interviews with residents, it was unclear whether forest cover was actually increasing. Intentional planting and spontaneous re-growth appeared to be occurring in El Tigre, but degradation was also likely since forests also represent an important source of fuel wood. The rates at which each was taking place were not readily apparent without confirmation (see chapter 4). However, an assessment of the perceived benefits revealed that increasing tree cover was likely.

When subjects were asked about their perceived value of forest products, responses were overwhelming positive (see Table 6.4) and varied little by gender or membership in the cooperative.

Table 6.4. Cross tabulation and Chi-square for perception of benefits of increasing tree cover.		
	Male	Female
No benefit	3	1
Shade/Aesthetic	3	1
Fruit	5	6
Fuel wood	6	0
Environmental Services	11	4
		Pearson X^2, *df*(4) = 5.9019, $p < 0.207$
	Member	Non-Member
No benefit	1	3
Shade/Aesthetic	3	1
Fruit	3	8
Fuel wood	3	3
Environmental Services	7	8
		Pearson X^2, *df*(4) = 3.5186, $p < 0.475$

The open-ended question yielded many responses from participants. Participants were asked to name which benefit was most important. That response was categorized into one of five general types: *no benefit* (subjects complained about trees competing for space or resources with traditional crops)[32]; *shade* or *aesthetic* purposes (subjects cited the most important benefit of trees was the value of shade, cooling characteristics, or the natural aesthetics of the trees); *fruit* (subjects reported intentional cultivation of fruit trees for supplemental income and/or household consumption); *fuel wood* (subjects reported intentional cultivation of fuel wood or the selective cutting on mountainsides for supplemental income and/or household consumption); and *environmental services* (a catch-all for a variety of responses that included improvements in soil, climate, rainfall,

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> Eventually these big trees that we planted became useless to us. What ended up happening was the tree kept sucking up the nutrients in the soil because it gets too hot. When this happens, it doesn't allow for other plants to grow in the same soil. As you can see with the plants I have here they lack nutrients. The two trees over there that I have are in an area where nothing will grow. You always want to plant something because if you don't, you risk the chance of growing other plants. (Female resident of Cantón El Tigre; Source: J. Kelly, field notes).

and environmental health such as reduced flooding and erosion). Most subjects also discussed the long-term benefits of backyard woodlots and orchards:

> You need to replenish the soil for [trees to grow successfully]. I have one manzana with three cashew trees and a few jocotes, but you need to reutilize the land to do this. Reforestation is good and if I don't benefit from it then the next generation will. (Male resident of Cantón El Tigre; Source: J. Kelly, field notes).

Results could have been improved by a larger sample, and while not statistically significant, gender appears to play an important role in that women most frequently cited fruit as the most important benefit of increased tree cover, compared to men. The small sample indicates that gendered agricultural participation may play an important role in forest cover change, as women are more likely to participate in orchard production than in traditional row cultivation (see chapter 5).

Perceptions and Experiences of Threats of Invasion, Eviction or Encroachment

I predicted that in a place where land tenure is secure that the perceptions of threats of invasion, eviction or encroachment would be minimal, regardless of the form of land tenure or of the sex of the head of household. Conceptualizations about social capital suggest that the cooperative, in particular, would serve as one of the most secure forms of land tenure since norms and rules would be established among members.

> In this area, there are no owners. (Elderly resident of Cantón El Tigre; Source: J. Kelly, field notes)

The idea that there were no owners was reinforced by the repeated descriptions of accountability among members of the cooperative. Subjects recounted events of disputes among neighbors that were resolved, not by authorities, but within the group. The success by which the democratically governed institution operated reinforced a sense among members that threats of invasion, eviction or encroachment were minimal.

> Thank God, no, I have never had problems with anyone trying to take my land. And there haven't been incidents where someone came here to reclaim this property. And you can't make up lies because someone like Amanda will know about it. (Female cooperative member in Cantón El Tigre; Source: J. Kelly, field notes)

When subjects were asked to rank their perceived level of risk, cooperative members were more likely to report risk than non-members (see Table 6.5).

Table 6.5. Cross tabulation and Chi-square for perception of risk of invasion, eviction, or encroachment.

	Male	Female
1-No risk	7	3
2-Minimal risk	3	1
3-Moderate risk	11	2
4-High risk	5	5
5-Occurance	2	1
		Pearson X^2, $df(4) = 3.2906$, $p < 0.510$
	Member	Non-Member
1-No risk	1	9
2-Minimal risk	2	2
3-Moderate risk	9	4
4-High risk	4	6
5-Occurance	1	2
		Pearson X^2, $df(4) = 8.3442$, $p < 0.080$

Explanations for the apparent discrepancy between accounts of tenure security may be explained by the inherent insecurity created in communal land tenure systems that may not be as relevant for those who have title or rent land in El Tigre, separately from the cooperative. That is, members of the cooperative are more likely to perceive threats to land tenure in the form of disagreements over what constitutes appropriate land uses, the management and distribution of products from communal lands, the division of parcels and proposed new memberships in the cooperative. Thus, upon analysis, risk within the cooperative is different from risk within the community. Members of the cooperative were more likely to rank and comment on perceived risk as it related to risk within the cooperative. However, non-members, when asked to rank and discuss, referred to risk within the community as a whole, where threats would come from neighbors (as the question was intended to reveal in the results). As such, an unanticipated view of risk was uncovered from the interviews. Residents on communal lands, while under virtually no risk of outside threat of eviction or encroachment, experience elevated perceptions of risk within the communal land tenure structure. The perceived risk within the communal structure suggests that the cooperative interfaces with the households in decision making on household plots for land use. Presumably, since men and women are represented disproportionately within the cooperative, risk within the communal structure may have a gendered component as well, as observed below.

Men and women reported risk with no statistically significant difference between the groups. However, larger sample size may have helped to demonstrate that a discernable difference was present, and it was observed more particularly in the way women discussed household relationships. Within households, land tenure security may be very different. Based on survey results, women generally gain access to land through their husbands, fathers, sons, and brothers, and access is generally limited to use rights. Of those interviewed, women regularly reported being excluded from household decision-making regarding land use when a male head of household was present. I interviewed Maria[33] who described the uncertainty of her future, since her sons' father was not legally her husband. While she occupied a parcel of land, her sons were the owners.

[33] Pseudonym to protect the subject's identity.

> This place is where I live but it is not mine. I make payments on the land, but when the payments are complete, it will belong to my sons. I have been hoping they will give me a small piece of this land, but I won't know where I will end up. You never know until that day comes…because right now this land is not mine. (Elderly female resident of El Tigre; Source: J. Kelly, field notes)

For another woman I interviewed, the uncertainty was the same, but the reasons for the unpredictability of the future were far different. When I arrived at our interview, Rosana[34] was picking up bricks around her home, of which only two outer walls remained standing and tarpaulin served as a roof. A severe rainstorm nearly a year earlier destroyed the house. Immediately after the event, her husband abandoned her and their three children. Since then, Rosana has been unable, and somewhat unwilling to make the repairs. The land is her husband's, and she fears that his relatives would force her out, if she were to invest in the property that she feels she cannot claim. Neither she nor her husband was associated with the cooperative.

> Well the problem is dealt with by the owner [Rosana's husband]. Since it is under his name, he must come and see what is happening on the property. Ever since he separated from me, he has not visited the property. By him not being here, he doesn't see the situation I am in now. (Rosana, resident of El Tigre; Source: J. Kelly, field notes).

Intra-family relationships, particularly for women, are likely more significant for the perceptions of risk of eviction than eviction by outsiders. As such, more work is necessary in this area to understand fully the dynamics of threats of eviction and land use and land cover change. Based on the earlier results and the previous discussion, it is no surprise that little may be gleaned from the few instances of actual occurrences with threats of land invasion, eviction and encroachment (see Table 6.6).

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[34] Pseudonym to protect the subject's identity.

Table 6.6. Cross tabulation and Chi-square for experiences of invasion, eviction, or encroachment.		
	Male	Female
Occurrence	1	1
No occurrence	27	11
Pearson X^2, *df*(1) = .4010, $p < 0.527$		
	Member	Non-Member
Occurrence	0	2
No occurrence	17	21
Pearson X^2, *df*(1) = 1.556, $p < 0.212$		

Statistically, there is no discernable relationship between factors related to events of invasion, eviction or encroachment. An increase in the number of observations would improve the discussion. Still, the low numbers of reported incidents by those interviewed confirm that land tenure is relatively secure on the local level in El Tigre. Of all subjects interviewed, only one person suggested calling the police or some other authority figure to resolve a dispute over land or boundaries. Others consistently agreed that because everyone in El Tigre "knows something about someone," incidences of invasion or encroachment were nearly non-existent.

Primary Income Activity in Agriculture

The residents of El Tigre participate in a variety of agricultural activities for subsistence and for supplementation in consumption and income. Subjects, when surveyed, provided detailed accounts of agricultural activity, observing the sex-based differences in men's work and women's work. Statistically, those observations appeared to be validated in that women were much more likely to participate in household gardens and orchards for agricultural production than were men (see Table 6.7). What this suggests is that if men continue to work in row cultivation and women are engaged in orchard production that there is a gendered aspect of forest cover increase in El Salvador, given that early observations suggest that a substantial proportion of forest increase in El Salvador is directly related to increases in orchard production.

Table 6.7. Cross tabulation and Chi-square for primary income activity in agriculture.		
	Male	Female
Animal husbandry	3	1
Row cultivation	20	4
HH gardens/orchards	1	7
Other	4	0
Pearson X^2, $df(3) = 16.39$, $p < 0.001$		
	Member	Non-Member
Animal husbandry	2	2
Row cultivation	13	11
HH gardens/orchards	2	6
Other	0	4
Pearson X^2, $df(3) = 5.38$, $p < 0.145$		

However, if this pattern is related to a domestic child-rearing cycle (where women engage in agricultural activities near the home), I was unsure why women were not more actively engaged in animal husbandry, particularly small animal husbandry. Angela's[35] account is somewhat revealing in why orchards are favored instead:

> There have some false rumors about owning livestock--that it will help bring in income. But in fact it doesn't and we struggle to maintain the livestock and land is too costly for that. I have been trying for four years to build another small house on the property but been unable to because there is no money. We end up eating tortillas and beans because we are unable to afford anything else. We try to eat what is available to supplement ourselves. (Angela; Source: J. Kelly, field notes).

In addition, the argument supports the expectation that animal husbandry may compete with other activities, particularly growing vegetables.

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[35] Pseudonym to protect subject's identity.

Angela's account was affirmed by over 75% of all the subjects interviewed; however, over 90% of households kept chickens for household consumption of the eggs. The household raising of chickens were often the least important among the agricultural activities as reported during the interviews.

Diversification in agriculture is perhaps the single most important reason why tree cover is increasing in El Tigre. Mauricio[36] attributed the increase in tree cover around homes to the shift in crops:

> [All] this [land] was worked on [in row cultivation] by the older generation back then [over 20 years ago], and now things have changed. People are growing yucca, jocotes, and fruits that are popular at the moment. If we talk about how the people worked on the lands in the past versus how the people are working now, you can see the difference in the methods that is used. The methods may favor the men though…but women are doing more with jocote at home. (Mauricio; Source: J. Kelly, field notes).

Subjects interviewed noticed that women were increasingly participating in all forms of agriculture, including row cultivation after young children were no longer at home. Seemingly, women had greater economic opportunity in agriculture with the shift towards orchards. Women with children at home had greater participation in activities that enabled them to supplement the activities of men at fields some distance from the residence.

The flow of remittances

At the national level, Ahuachapán has relatively low out-migration compared to the national average for all departments. My findings in El Tigre are somewhat inconsistent in that many households report out-migration; and, nearly half of all out-migration may be described as permanent with no remittances received by the sending

[36] Pseudonym to protect subject's identity.

household.[37] In addition, low levels of remittance incomes are reported by those households with returns (see Table 6.8).

Table 6.8. Reported out-migration and remittances for Cantón El Tigre.				
Percentage of households with at least one member out-migrated	Percentage of Sending Households Receiving Cash Remittances	Percentage of Sending Households Receiving In-Kind Remittances	Percentage of Sending Households Receiving Both Cash and In-Kind Remittances	Percentage of Sending Households Receiving No Remittances
42.50%	17.60%	23.53%	11.80%	47.06%
n = 40 Source: J. Kelly, field notes				

Children tend to remain in the house until they decide to migrate, marry or the head of the household decides to provide them with a portion of the farm plot. Overall, the results of the interviews reveal that heads of household overwhelming prefer that their children, regardless of sex, remain on the land or in the community (Kelly, field notes). When queried about this preference, many discussed the reports of failed migration attempts to countries abroad (particularly to the US), problems of violence in San Salvador and in other urban areas of El Salvador (particularly in gangs and to women generally), and memories of experiences of disrupted families as a result of the war, for some (particularly more recent residents of El Tigre who may have migrated from another part of the country).

Results indicate that remittances likely have greater importance in overall household income where women are heads of household (see Table 6.9). Female heads of household are more likely than male heads of household to have remittance income. As

[37] I expect that the accuracy of remittance data here is poor or incomplete at best, given the reluctance of respondents to report income. This will account, in part, for the discrepancy between El Tigre and the measures for the department.

many as half of all female heads of household interviewed received some form of remittance, as either in-kind, cash, or a combination of both.

Table 6.9. Cross tabulation and Chi-square for remittance receipts.		
	Male	Female
Remittances	3	6
No remittances	25	6
		Pearson X^2, $df(1) = 7.4347$, $p < 0.006$
	Member	Non-Member
Remittances	4	5
No remittances	13	18
		Pearson X^2, $df(1) = 0.0180$, $p < 0.893$

The results appear to support the evidence that remittances may serve as a substitute for the mass rural out-migration, mirroring the economic development path of the forest transition theory. Yet coupled with observations of what women are doing with the remittance monies, I can reject that theory as it applies to El Tigre. Women receiving remittances are not usually allowing the spontaneous regeneration of forests, though as many as two in the sample did. Several of the others used remittance income to invest in backyard orchards and gardens, signifying that both gender and remittance incomes are important in the success of tree cover increase via orchard production.

Tree cover at the household-level

Significant tree cover was observed at over half of all households. Tree cover was described as significant if more than 25% of the household parcel was forested in the form of orchards, successional forest, living fences, and scrub growth. While no statistically significant relationship could be discerned from the relationship between tree cover and sex or tree cover and membership in the cooperative (see Table 6.10), results are promising in that there appears to be a possible relationship between sex of head of household and forest cover, even though it may not be expected in a place where tenure is secure. Yet, the results do not account for the gendered relationships within the household that could not be accurately captured by the statistical analysis. During the interviews, several participants described how and why trees were planted. Several female heads of household, as primary decision-makers, planted trees with remittance monies; but other female heads of household without remittance incomes were observed to less often have productive backyard orchards than those who had received remittances. Yet, fruit tree cultivation was readily observed in household lots where males remained as heads of household, but men were less likely to be responsible for agro-forestry activities. The discrepancy suggests that women, whether as heads of household or as members, are the driving force behind increases in backyard orchards.

Table 6.10. Cross tabulation and Chi-square for observations of tree cover on household parcels.

	Male	Female
Significant tree cover	20	6
Minimal tree cover	8	6
Pearson X^2, $df(1) = 1.6954$, $p < 0.193$		
	Member	Non-Member
Significant tree cover	13	13
Minimal tree cover	4	10
Pearson X^2, $df(1) = 1.7099$, $p < 0.191$		

El Tigre and Forest Transition Theory

The pattern in El Tigre, if in fact forest cover is increasing, appears to be similar to the pattern along the forest scarcity path, observed more often in Africa and Asia.

Because planting of trees is largely intention, it does not take on the regional characteristics more typical of Latin America. The economic development path, whereby forests spontaneously regenerate after rural out-migration, has been observed consistently in Latin America (Aide and Grau 2004). The intentional planting of trees, in the forest scarcity path, illustrates an integral role of humans in altering the landscape in forest transition theory, as opposed to the less direct role that humans play along the economic development path.

Through intentional reforestation, humans are improving the quality of soils in places where populations have not declined:

> What I tried to do here was plant trees in the first year. There were about 50 trees that I planted in which only a few trees survived because this soil was like clay and the trees dried up easily. Later I planted cashews which only a few grew because of the bad soil. As a result of the soil there are areas filled with trees and others without. The soil now is not the same as before because it has gotten better. This is how it is now where there are areas with trees and some areas that are clay. Little by little I have tried to plant other things around the area in hopes of growing something and making the best out of what we have here. (Female resident, Cantón El Tigre; Source: J. Kelly, field notes).

Intentional forestation, even in densely populated areas, has encouraged stabilization of degraded environments. The pattern has been observed elsewhere (Netting 1993) in places where forest transition has occurred along the forest scarcity path.

In sum, the perceptions of forests and forest benefits and the demand for forest products appear to be increasing, and as such, the preconditions for a forest recovery have been met. Additional survey results may yield a more definitive picture of the important of gender, land tenure, and social capital. Still, the results of analysis in El Salvador, and particularly in El Tigre, suggest that gendered land use decision-making is relevant and significant to forest cover change and forest transitions.

Chapter VII: Conclusion

As society more progressively values environmental services and timber and non-timber forest products provided by recovering and expanding forests, scholars demand improved measures and understanding of the contextual conditions surrounding forest cover change for the purposes of better informing resource management and policy. Forest transition theory potentially provides a theoretical tool that outlines the forces that drive forest cover changes, implicitly suggesting policy targets that would hasten the onset of forest recovery. Forest transition theory is critical in offering an explanation of the forces that drive recovering and expanding forests after a period of extensive deforestation. What is new here is that forest recovery may not be the product of the same set of assumptions in all places (Mather 1992; Mather and Needle 1998). Gendered land uses and issues of land tenure insecurity currently have no place in forest transition theory as currently constituted, but as demonstrated in El Salvador, consideration of these factors is important in more fully accounting for forest recovery in the tropics.

In the theory's original formulation, forest recoveries are likely prompted by increases in the demands for forest products and services, changes in population trends, and increasingly positive perceptions of forest resources. The theorized shift from net deforestation to net reforestation assumes that the conditions in the tropics are similar to those previously observed in the case studies of Europe and North America. The general pattern of forest recovery in Latin America, as described by Aide and Grau, does appear to follow the economic recovery path (Rudel et al. 2005), where poor farmers leave rural regions to search for employment in urban centers (Aide and Grau 2004). Consistent with

Mather's description of forest recovery associated with population decline in the countryside and agricultural intensification, rural out-migration results in land abandonment and spontaneous regeneration of forests in Latin America. El Salvador, however, does not fit the pattern of forest recoveries observed in other parts of Latin America. Since El Salvador is starting with relatively low levels of forest cover compared to other Latin American countries where a reversal of forest cover change has occurred (i.e. Puerto Rico, Dominican Republic), one might expect to find something different in the case of El Salvador. El Salvador is unusual in that it has experienced net forest cover increase while rural population densities remain high.

The case study of Cantón El Tigre in western El Salvador demonstrates that in some parts of Latin America, rural population density remains high, and forests still recover, even in the absence of substantial remittance incomes that may have otherwise substituted for mass out-migration and reduction in agriculture. In the western region of El Salvador, increases in population density, proportion of women in agriculture and proximity to San Salvador were positively correlated with increases in forest cover.

Much of that recovery comes in the forms of orchards, woodlots, living fences, shade-grown coffee cultivation, and some secondary forest recovery. The pattern is more consistent with the forest scarcity path which describes the intentional restoration of forests due to increased value of forest products in a newly industrializing society; however, the pattern described by Rudel et al. (2005) does not account for the gender and land tenure dimensions that are recognized in the El Salvador case. Thus, the account may be articulated as having followed a forest scarcity path with a heretofore unrecognized gendered component.

According to findings from fieldwork in El Tigre, the gendered nature of agricultural activities and land use is significant in explaining why forests may be returning to El Salvador. Women interviewed were less likely to participate in agricultural activities that drew them away from the household, but more likely to participate in those activities that could be undertaken near the home. These activities included animal husbandry, vegetable gardens, and orchards. More recently, orchards are gaining in popularity.

Women were especially devoted to the strategy, though both men and women participated in planting and tending to fruit trees. Overall, women cited several reasons for the increasing support of orchard-growing activities: 1) fruit provided sustenance for the family; 2) surplus fruit could be sold locally; and 3) trees provided aesthetic value and additional environmental services (i.e., providing soil stabilization and enhanced soil fertility in an erosion-prone area). The case appears to be more consistent with the observations of forest recovery in East Africa, where women in densely settled agricultural lands planted more trees, proximately located near markets where surplus fruits and fuel could be sold.

In El Tigre, land tenure is relatively secure. People are unlikely to invest in fruit trees and woodlots where tenure is not secure. Since fruit trees and woodlots take several years before becoming fully productive, orchards and woodlots represent a long-term investment—one that would not be undertaken unless some degree of tenure security existed. According to most of those interviewed in El Tigre, heads of household often did not have secure title to land, but rather an alternative form of security in the communal land holdings of the cooperative.

Social capital is currently one of the most important ways by which residents of El Tigre are able to enjoy a higher degree of tenure security and security in investment. Compared to other parts of El Salvador, particularly in the north, El Tigre was not severely affected by the civil war of the 1980s in the sense that the resident population was continuous, or as one subject stated, “everyone knows everyone here.” The implication was that boundary disputes were relatively rare, and most residents could be certain that an investment in land would be protected by the knowledge that others in the community recognized each other’s rights to a parcel.

Still, some degree of uncertainty does exist in the communal land tenure arrangement, as recognized in earlier studies of forest cover change and cooperatives in El Salvador (Blackman, Avalos-Sartorio, and Chow 2008); however, much of this insecurity relates to conflict within the cooperative with respect to land use decisions and responsibilities in management, division of parcels, and membership and access within the cooperative.

In other parts of El Salvador, particularly in the northern region, land tenure is less secure, and the social structure of communities there was severely disrupted by the civil war of the 1980s. With high population density, forest recovery might again be unlikely. Yet, forests are returning. Forest recovery in the north likely differs from forest recovery observed near El Tigre. Since the northern region is considerably less connected to urban centers and the terrain is more rugged, some forest recovery may be consistent with land abandonment in peripheral areas of little agricultural value. In addition, some forest recovery may be associated with orchards and woodlots near homes. To some degree the conclusion that forest recovery takes the mixed path of both economic development and forest scarcity is conjecture that warrants addition investigation, but multivariate regression analysis reveals that gender is much more significant in predicting forest cover change in the north than had been the case in the west. As a result of heavy out-migration by males, households are more often headed by women in the northern region than in the west. An investigation into household land use decisions in the north would reveal important, additional information about the gendered dynamics of forest cover change there.

The national analysis of forest cover change and drivers of such change reveal that recovery is indeed regionalized. Forest transition theory is formulated as a national explanation of net forest cover change, and as such, it is not usually appropriate in a geographically expansive country, where regional changes are pronounced. However, this case also reveals that a national explanation of forest cover change does not necessarily apply equally across all regions, even in a small country like El Salvador. Regression analyses revealed that population density likely interacts with gender to produce increases in forest and that regions matter with respect to trends in forest cover change.

In all regions, the increase in the proportion of women working in agriculture had a positive effect on forest cover change, despite some of the concerns about the data (i.e. changes in fertility and death rates from the 1992 census to the observation of forest cover change in 2000-2005). Improvement in the analysis may be achieved by conducting additional regression analyses that weight the areas of the municipalities (instead of including it as a predictor variable) and by conducting a test of spatial auto-correlation. I suspect that there is some evidence of spatial auto-correlation. These uncertainties, notwithstanding, the results from these analyses strongly suggest forest transition in El Salvador is a highly gendered process.

Given that there are no actors in forest transition theory (only forces that conceive of people in an abstracted sense), the activities of rural people on the landscape are somewhat lost in the theory. Women plant trees for sustenance and profit, but more importantly, it also appears that women are also planting in places where tenure is more precarious. It is possible that they plant trees as a way of strengthening their claims to land, as observed in East Africa (Ng'weno 2001). This last claim will require future research.

Further research is required to understand the local drivers of forest cover change in northern El Salvador. Such research, in the form of additional ethnographies, could help to reveal the context whereby men and women are encouraging positive or negative forest cover change. However, the research on the drivers must also be paired with reliable data on forest cover change.

The observed forest cover (and subsequent changes) in western El Salvador can be more accurately characterized as forest that is highly managed and manipulated as a form of land use—in that forest cover change in El Salvador is not typically spontaneous regeneration, but rather a form of agriculture. The difference may be relevant to discussions of what forest recovery in El Salvador means for the global scale of the benefits of reforestation for environmental services, particularly as a form of climate change abatement.

Given that forest cover change in El Salvador is made up of forests with relatively poor biodiversity and with low canopy cover, one might suspect that the most liberal definitions of forest must be used in order to characterize the landscape changes in El Salvador as a genuine land transition. The observed patterns of forest cover change in El Salvador today suggest that coarse resolution imagery is less likely than high resolution imagery to capture the increases in forest cover that is made up of living fences and small backyard orchards, but it is in these places that forest cover is increasing most rapidly and is most often overlooked in forest cover change analyses using remotely sensed imagery.

The significance of the changes in forest cover is felt at the global scale (where an additional forest transition in the tropics may be occurring and providing added environmental services) and the local scale (where women are increasingly securing claims to land and livelihood). Although the forest transition in El Salvador may be an insignificant compared to the large-scale global effort to reduce deforestation and encourage reforestation, it represents a case where even in a degraded environment, net forest increase in the form of agro-forestry helps to restore fragile and depleted ecosystems, sequester carbon, and reduce the vulnerabilities felt by rural peoples. For these reasons, scholars should consider these forests valuable and worthy of consideration in their attempts to characterize forest cover change and promote policies that accelerate forest recoveries.

Appendix A: Interview Schedule for Farmers

Oral History

1. How long have you lived on your land? In your community?
2. Would you describe how the land and land use has changed over the last 20 years?
3. Do you own livestock? What types of animals? Do you own more or fewer animals in the last 10 years? 5 years?
4. What are the techniques used to cultivate your land?
5. Are techniques such as terracing or rotation used?
6. How has the level of forestation on your property changed in the last 20 years? 10 years? 5 years?
7. What is your daily routine?
8. What are the major differences in your routine during the years? Each month? When do you plant, harvest?

Land Tenure

1. Do you own the land(s) you cultivate? Live on?
2. Do you have the title(s)?
3. If not you, who owns the land(s)?
4. How do you think the opportunity to acquire land in this area has changed in the last 20 years?
5. Do you know if the majority of people living in this area are the owners of the land on which they live?
6. Do you believe that reforestation on your land is beneficial? In what ways?

7. Do you fear that your land will be appropriated? Would you rank your level of fear?
8. Are there resources you could access in the case of someone attempting to appropriate your land?
9. Would you seek the help of the authorities or police in case of an attempted appropriation?
10. Do you think there are some actions you can take to avoid or diminish the risk of appropriation?
11. Have you had disputes with your neighbors over where your property line is?
12. In the case of an existing dispute with a neighbor, are there resources you have sought out to reach a solution?
13. Have you been the victim of appropriation?
14. How is the land distributed in this community?
15. Is it common for the youth to need to need for work outside of the community? For how long? To where? When do they return?

Household Income

1. What types of economic activities do people in the home take part in? Which activities represent the majority of household income?
2. Are there family members in San Salvador, in another city, or abroad that send money?
3. Does anyone send gifts? What types of gifts do they send? How much or how often do they send gifts?

4. Can you tell me the proportions of remittances, gifts, or your household activities that make up the income of the household?
5. What percentage would you say remittances make up the household income? Others?

Demography

1. Name, age, and sex of the interviewed person.
2. How many people live with you? What are their ages?
3. How many people contribute to the household income?
4. What levels of schooling do the members of the household have?

Mapping

1. Would you show me your property? What kinds of activities take place here?
2. Can we talk about how you might map these activities? (Sketch maps)

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Curriculum Vita

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Education

2009	Doctor of Philosophy, Geography Rutgers, The State University of New Jersey
2003	Master of Arts, Energy & Environmental Analysis Boston University
2003	Bachelor of Arts, Dual Program: Environmental Analysis & Policy, Economics Boston University

Publications

2009	Kelly, Jessica J. Review of Moss, Pamela, and Karen Falconer Al-Hindi, eds. 2008. Feminisms in Geography: Rethinking Space, Place, and Knowledges. New York: Rowman & Littlefield. *Signs: Journal of Women in Cultural and Society*, 34(4): 1020-1022.
2007	Kelly, Jessica J. Review of Dowler, Lorraine, Josephine Carubia, and Bonj Szczgiel, eds. 2005. Gender and Landscape: Renegotiating Morality and Space. London: Routledge. *Journal of Cultural Geography*. 24(2): 99-101.

Professional Experience

2008-present	Assistant Professor, Environmental Geography. Department of Geography, Millersville University, Millersville, PA.
2007-present	Reader. Princeton Review, Advanced Placement Human Geography.
2007-2008	Fellowship Advisor. The Resource Center for Graduate Student External Support, Graduate School-New Brunswick, Rutgers University.
2005-2007	Teaching Assistant. Geography Department, Rutgers University.
2004-present	Adjunct Instructor. Keystone College, LaPlume, PA.
2003-2008	Lecturer. Geography Department, Rutgers University.
2002-2003	Assistant and Staff Coordinator to Andrew W. Mellon Professor and Nobel Laureate Elie Wiesel. Boston University, Boston, MA.