Tree Cover Loss in El Salvador's Shade Coffee Areas

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An RFF Report

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Contents

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EXECUTIVE SUMMARY

A. Background and objectives

In 2001, after decades of gradual decline interrupted by short-term spikes, inflation-adjusted world coffee prices dropped to their lowest levels in a half century. The causes of this price shock, commonly referred to as the coffee crisis, included increased production in Vietnam and Brazil, weak demand for low-end coffee, and growing concentration in the roasting sector. Because these factors are structural rather than cyclical, prices are unlikely to rebound dramatically in the short term (Varangis et al. 2003). The coffee crisis has resulted in significant economic hardship in Central America, where coffee is a leading agricultural sector. Between 1999 and 2001, Central American export earnings from coffee declined by 45%, while employment fell by about 25% (World Bank 2005a).

In addition to economic dislocation, the coffee crisis is also having serious adverse environmental impacts. A joint report by the Inter-American Development Bank (IADB), the U.S. Agency for International Development, and the World Bank highlighted three impacts (IADB et al. 2002). First, coffee beans left to rot on abandoned or neglected farms exacerbate plagues and pest infestations. Second, efforts to promote environmentally friendly practices at processing plants have fallen off. Third and most important, the coffee crisis has led to a loss of tree cover and related ecological services. Why?

The lion's share of coffee in Central America is grown in the shade of woody perennials—either the existing forest or managed tree cover. This mixed agroforestry system provides both private benefits to coffee growers and public benefits to society at large. As for the former, it moderates temperature, promotes the retention of soil moisture, generates organic matter that serves as natural fertilizer, and serves as habitat

[1] Allen Blackman is a senior fellow at Resources for the Future and may be reached at (202) 328-5073 or blackman@rff.org. Beatriz Ávalos-Sartorio is a senior agricultural research officer at the Consultative Group for International Agricultural Research; Jeffrey Chow a research assistant at Resources for the Future; and Francisco Aguilar a doctoral candidate at Louisiana State University.

for birds that eat harmful insects. As for the latter, it provides a number of vital ecological services, including harboring biodiversity, sequestering carbon, facilitating aquifer recharge, and preventing soil erosion. The biodiversity benefits are particularly notable. Shade coffee often grows in mountain ranges at altitudes where tropical and temperate climates overlap, areas that are extremely rich in biodiversity (Rice 2003; Perfecto et al. 1996).

Unfortunately, as coffee prices have declined, tree cover in shade coffee areas has been cleared. Some growers have migrated to cities to find employment, abandoning their farms and leaving them vulnerable to encroachment by conventional farmers, ranchers, and loggers. Others continue to grow coffee but have cleared forest on and around their farms to sell the timber, grow subsistence crops, and raise livestock. Still other growers have sold their land to developers. No matter what the proximate cause, the end result has been significant loss of tree cover along with the ecological services it provides. The environmental damages from deforestation in shade coffee regions can be significant, and some of it—notably species loss and soil erosion—may be irreversible or nearly so.

Despite growing concern, tree cover loss in Central American shade coffee growing areas remains poorly understood. Little is known about the magnitude, characteristics, and drivers of this loss. Approximately how much tree cover has been lost in each country? Does deforestation occur in peri-urban areas or in more remote rural areas? In regions dominated by small farms or large ones? Does it occur on certain types of soil or in certain institutional environments? Answers to such questions can help policy makers design effective strategies for stemming deforestation in shade coffee regions.

The present study aims to help fill this gap. We focus on El Salvador for a number of reasons. First, the country's coffee areas are vitally important ecologically. El Salvador is the most densely populated country in Latin America and also the most severely deforested. Less than 10% of its natural forests survive, and the vast majority of remaining tree cover is associated with shade coffee (FAO 2002). Second, although anecdotal evidence strongly suggests that even this tree cover is now rapidly disappearing, virtually no hard data exist on the magnitude, characteristics, and drivers of this tree cover loss. Finally, the digital land cover maps derived from satellite images needed for a detailed empirical analysis are available. Our data requirements are discussed in more detail below.

We focus on the decade of the 1990s because our land cover maps are derived from 1990 and 2000 satellite images. The extent to which our study period coincides with—or predates—the "coffee crisis" is open to question; a precise definition of this term does not exist. Recent studies frequently use it to refer to the precipitous decline of prices between 1997 and 2001 (e.g., Varangis et al. 2003; World Bank 2005a). However, the overall downward trend in coffee prices that culminated in this steep five-year slide began decades earlier, and many researchers use the 1989 collapse of the International Coffee Agreements (ICA) quota system to mark the start of the coffee crisis (e.g., Ponte 2002; Gresser and Tickell 2002).[2] Hence, using the first definition, our study period overlaps with the last three years of the coffee crisis. Using the second definition, it covers a ten-year period in the middle of the crisis. In both cases, however, our study period misses the trough in prices that occurred in 2001. We return to this issue later in the report.

The study was conducted by Resources for the Future (RFF), a non-profit environmental policy research institute in Washington, DC, with the assistance of the Salvadoran Coffee Research Institute (*Fundación Salvadoreña para Investigatciones del Café*–PROCAFE). It follows on a 2000–2003 study of tree cover loss in Mexican coffee areas carried out by RFF in collaboration with Universidad del Mar (UMAR), a public University in Puerto Angel, Oaxaca (Blackman et al. 2003 and 2005). Funding for the present study was provided by the IADB and the Tinker Foundation.

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- generate data on the magnitude and spatial pattern of tree cover loss in El Salvador's shade coffee areas from 1990–2000;
- identify the key factors driving this loss;
- develop a fine-scale map of the predicted probability of further tree cover loss; and
- present policy recommendations.

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B. Methods overview

The methods used in this study are detailed in the body of the report. Here, we provide a brief overview of the main tasks involved.

i. Gathered background information

To help design the econometric analysis described below and then interpret the results, we gathered background information on the Salvadoran coffee sector and on tree cover loss in the country's coffee areas. Much of these data were collected in the course of a two-week trip to El Salvador. During the trip, we interviewed 24 representatives of coffee cooperatives, government regulatory agencies, trade associations, coffee exporters, development banks, non-governmental organization (NGOs), and research institutes (see Appendix 1 for a complete list).

ii. Mapped tree cover change

We generated detailed spatial data on tree cover loss in El Salvador's coffee areas by comparing a 1990 digital land cover map of the country derived from LANDSAT satellite images with a compatible digital map for 2000. The maps were provided by NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California.[3]

iii. Constructed a geographic information system

We constructed a geographic information system (GIS) for El Salvador's coffee areas that contains the above-mentioned tree cover loss data as well as a wide array of data on the geophysical, institutional, socioeconomic, and agronomic characteristics of these areas.

iv. Conducted econometric regression analysis

We used regression analysis to identify the key drivers of tree cover loss in El Salvador's coffee areas between 1990 and 2000. To do this, we first drew a random sample of approximately 30,000 57-meter square plots from our GIS. Next, we ran a series of probit regressions in which the dependent variable was a measure of tree cover change between 1990 and 2000 on each plot, and the independent variables were proxies

[3] Dr. Sassan Saatchi, a Senior Researcher at JPL, supervised the creation of the maps and generously agreed to let us use them for this project.

for, or measures of, the geophysical, institutional, and agronomic, and socioeconomic characteristics of each plot. We used a farm-level model of land use to underpin the econometric analysis.

v. Constructed deforestation risk maps

We used our econometric model to generate predicted probabilities of clearing on plots in coffee areas that remained forested in 2000.

vi. Developed policy prescriptions

Finally, we reviewed our findings to distill lessons for the design of polices to stem deforestation.

C. Key findings

The following are the principal findings from our study.

i. Until the 1990s, shade coffee likely provided a bulwark against tree cover loss.

Until the 1990s, a much higher percentage of land inside El Salvador's coffee areas than outside of them retained tree cover. In 1990, 93% of the land inside coffee areas had some type of tree cover, while only 49% of the land outside of these areas did. Hence, historically, coffee appears to have provided a bulwark against tree cover loss in El Salvador.

ii. Tree cover loss in coffee areas during the 1990s was extensive.

During the 1990s, 13% of the land inside El Salvador's three main coffee growing areas was cleared. This percentage was slightly higher than that for land outside of the coffee areas (12%).

iii. Of the three main coffee regions (west, center, and east), the west region experienced the most clearing.

During the 1990s, 17% of the land in the west coffee region was cleared, 11% of the land in the center region was cleared, and 7% of the land in the east region was cleared.

iv. Contrary to conventional wisdom, most clearing in coffee regions during the 1990s occurred in middle- and high-altitude areas, not in lowland areas.

For the entire country, 46% of clearing in coffee areas during the 1990s occurred between 800 meters above sea level (m.s.l.) and 1,200 m.s.l., where coffee is classified as "high grown" and 15% occurred above 1,200 m.s.l., where coffee is classified as "strictly high grown." Only 39% of all clearing occurred below 800 m.s.l.

v. During the 1990s, clearing was fragmented and patchy.

Clearing during the 1990s did not occur in large contiguous areas. The reasons that clearing occurred in some areas and not in others are not immediately obvious.

vi. In addition to declining coffee prices, a complex web of inter-related factors—including a downward spiral of on-farm investment and yields; debt; poverty; urbanization; migration; land reform; and weak land use and land cover regulation—contributed to falling coffee profits and consequent tree cover loss in the 1990s.

In a broad sense, clearing in coffee areas during the 1990s can be attributed to a sharp decline in profits from coffee farming relative to profits from other land uses such as housing, row agriculture, and livestock. Although low coffee prices were undoubtedly an important factor driving this phenomenon, an array of intertwined factors contributed to it. These included:

- a *downward spiral of on-farm investment and yields* touched off when low prices led growers to cut back on "discretionary" farm management and investment, which depressed yields, which further depressed profits, which resulted in more cuts in management and investment;

- mounting *debt* that: (a) dampened short- and long-term investment in the coffee sector either because banks cut lending to indebted borrowers, or because retained earnings that normally would have been invested were instead devoted to servicing debt; (b) led directly to tree cover loss in cases where banks foreclosed on land used as collateral and resold it to developers, ranchers, and farmers; and (c) created incentives for growers to sell their land or the trees on it to repay their debts;

- *poverty* that led: (a) small-scale growers unable to meet their basic needs from coffee alone to clear portions of their farms in order to grow subsistence crops; and (b) rural households to harvest trees and sell them as lumber and firewood;

- *urbanization* that raised the return on converting coffee land to housing developments and other urban uses;

- *migration*, especially from the eastern parts of the country, that fueled urbanization by: (a) generating remittances used to purchase houses (when migration was external); and (b) increasing population density in the center and west parts of the country (when migration was internal);

- *land reform* that, notwithstanding important social benefits, led to the creation of a class of new growers with limited management experience; and

- *weak land use and land cover regulation*.

vii. Although hard evidence on the exact land uses changes that led to tree cover loss is lacking, PROCAFE regional managers estimate that urbanization was responsible for 50–90% of clearing in each coffee region during the 1990s.

PROCAFE managers estimate that urbanization was responsible for 90% of clearing in the west region, 70% in the center region, and 50% in the east region. Among other land uses substituted for coffee during the 1990s, row crops were thought to be responsible for 5–10% of clearing in each region, while harvesting lumber and firewood were thought to be responsible for 20% of clearing in the east region.

viii. An array of policies and programs that have the potential to help slow tree cover loss in shade coffee areas are ongoing, planned, or under discussion. However, for the most part, these efforts ignore spatial differences in the risk of further tree cover loss. Ongoing initiatives include:

- subsidized credit and debt relief for coffee growers;

- payments for environmental services programs that would provide financial incentives for coffee growers to retain tree cover;

- command-and-control measures including new land use planning legislation and improved protected areas management; and

- programs to help growers improve coffee quality and marketing; diversify into alternative tree crops; and improve farm management.

ix. The probability that any given plot in El Salvador's coffee areas was cleared during the 1990s depended upon its geophysical, institutional, agronomic, and socioeconomic characteristics in ways that were complex, differed across the three coffee regions, and often contradicted conventional wisdom. This complexity reflects the fact that a variety of very different land uses were displacing coffee during the 1990s. All other things equal, clearing was more likely to have occurred on plots:

- *in the west and center* coffee regions;
- *farther from coffee export markets* (the two cities from which all Salvadoran coffee is exported) in the east region;
- *close to major cities* in the center region but far from major cities in the east region;
- *at high altitudes* (above 800 m.s.l.) in the center and west regions, but at low altitudes in the east region;
- that were *relatively flat* in the west and east regions;
- that were *north-facing* in the west and east regions;
- in cantons where an above-average share of land was held by *reform cooperatives* in the east region, but in cantons where a below-average share of land was held by reform cooperatives in the west region;
- that were outside the boundaries of a *legally protected area* in the west and east regions, but that were inside such areas in the center region;
- in cantons that had a relatively high percentage of *large farms* in the center region;
- in cantons that were relatively *densely populated* in the center and west regions; and
- in cantons that had a relatively low percentage of *female headed households* (a proxy for *migration and remittances*) in the east and west regions.

Three general comments about these results are in order. First, several defy conventional wisdom and shed light on contested issues. Conventional wisdom holds that during the 1990s, clearing mainly occurred in lowland areas that produce inferior quality (generally less profitable) coffee and that reform cooperatives were responsible for a disproportionate percentage of clearing. However, we found clearing was more likely at high altitudes in the west and center regions and in areas where a below-average share of land was held by reform cooperatives in the west coffee region. The effects of farm size and remittances on clearing have been the subjects of considerable debate. Our results suggest that large farms were responsible for a disproportionate share of clearing in the center region, and that remittances discouraged clearing in the west and east regions.

Second, a consistent underlying story would appear to explain many of the difference in econometric results across regions: urbanization drove deforestation in the west and center, while subsistence agriculture and logging were important in the east. Specifically, we found that in the west and/or center regions, clearing was positively correlated with population density, proximity to major cities, large farm size and higher altitudes (large farms at higher altitudes are the preferred targets of developers). In the east region, by contrast, we found that clearing was negatively correlated with proximity to major cities and with higher altitudes (row agriculture is better suited to low altitudes). This underlying story comports with anecdotal evidence provided by PROCAFE about the relative importance of clearing in the west and center versus the east regions.

Finally, our results provide additional support for the hypothesis proposed by Blackman et al. (2004) that in shade coffee regions, clearing is more likely to occur far from major markets, the opposite of the pattern in natural forests.

D. Policy prescriptions

i. A rapid policy response is needed.

Although historically, shade coffee appears to have provided a bulwark against deforestation, this no longer appears to be the case. During the 1990s, tree cover in shade coffee areas was lost at a rapid rate and there is ample reason to suspect that this trend has continued apace given that coffee prices reached a 50-year low in 2001 and have remained well below $1 per pound since then. To preserve what tree cover remains, and to prevent soil erosion, flooding, biodiversity loss, and other types of environmental degradation that would result from further deforestation, action must be taken quickly. Moreover, because the coffee crisis has set in motion the downward spiral of on-farm investment and yields, the problem is only likely to become more difficult to address with the passage of time.

ii. Policies and programs to conserve tree cover in shade coffee areas must be carefully targeted and tailored.

Policy responses need to be carefully targeted and tailored to specific locations and institutional settings. Our results indicate that the drivers and characteristics of clearing differ across the three coffee regions. For example, clearing in the east was more likely to have occurred in lowland areas far from cities and markets, a finding that suggests it was driven in large part by logging and subsistence agriculture. In the center and west, by contrast, clearing was more likely to have occurred in densely populated highland areas in close proximity to cities, a finding that suggests it was driven mainly by urbanization. Given such heterogeneity, one-size-fits-all approaches are almost certain to be ineffective and inefficient. For example, a policy that only targeted coffee farms in lowland areas would not address the bulk of tree cover loss, which is occurring in the center and west highland areas, and a policy that only targeted coffee farms in close proximity to cities would miss clearing that is occurring in rural areas in the east region. The "deforestation pressure" map described in Section 5.6 could be an ideal tool for targeting forest conservation policies.

iii. Command-and-control policies are needed to stem tree cover loss due to urbanization but are not likely to be effective in the short- to medium-term.

Our research suggests that urbanization, along with a host of intertwined factors (including speculation and an inflow of financial capital from remittances), have dramatically inflated land prices in coffee areas, thereby creating strong incentives for coffee growers to earn windfall profits by selling their farms to developers. Furthermore, this phenomenon appears to be a key driver of land use change in some coffee areas. In such areas, market-based forest conservation approaches, such as payments for environmental services (PES) and coffee certification programs, are not likely to be effective when used in isolation; that is, absent complementary command-and-control policies. In areas where land prices and urbanization are driving land use changes, it is hard to imagine PES or certification programs that could provide financial incentives on par with the land market.

The alternative to market-based incentives is conventional command-and-control land use and land cover regulation.[4] In our view, such regulation is absolutely necessary

[4] Another option is to levy taxes on urban development in shade coffee areas that are sufficiently high as to deter all but the most profitable land use changes.

to control tree cover loss in El Salvador's coffee areas where urbanization is driving land use changes. Unfortunately, however, it is not likely to be effective in the short- to medium-term. To date, by all accounts, land use and land cover regulation in El Salvador has proven toothless. Regulatory authorities apparently lack the institutional capacity and political will to counter the powerful economic and political forces driving urbanization and other types of land use change. New national land use planning legislation is reportedly imminent. However, building the institutional capacity to implement it will take some time. Absent a dramatic shift in policy or market conditions, there is little reason to be optimistic that tree cover loss due to urbanization in coffee areas can be reversed in the next five years.

Having said this, three strategies may help to slow this phenomenon. One is to create incentives for land developers to clear and build in a manner that minimizes environmental degradation by, for example, retaining as much tree cover as possible, avoiding ecologically sensitive areas, and retaining corridors between forested areas. A second strategy is to combine market-based incentives and command-and-control policies, as hybrid policies may prove more effective than one-dimensional policies. Finally, policymakers can ensure that coffee growers who have the potential to turn a profit under current market conditions have access to credit as well as a feasible strategy for making good on past debts. Presumably, growers who lack access to working capital and those who see no way to climb out from under their financial obligations are most liable to trade a stream of future income from coffee for a one-time windfall profit from the sale of land. However, credit market interventions—and, in particular, conventional debt relief—are only advisable if they can be structured in a manner that all but eliminates perverse incentives for non-repayment and regressive distributional impacts.

iv. Encourage efforts to improve coffee quality and marketing.

One of the most promising recent developments in the Salvadoran coffee sector has been the success of efforts to improve coffee quality and marketing, particularly in highland areas that are well-suited to producing high-end coffee. By enabling growers to access a more remuniterative segment of the coffee market, these efforts are generating substantial economic benefits. But what effect are they having on deforestation?

Conventional wisdom holds that the lion's share of deforestation in shade coffee areas is occurring at low altitudes. The implication is that efforts to improve coffee quality and marketing in highland areas miss the mark in terms of ecological benefits.

Our results suggest the opposite, however. We find that in the center and west regions, the lion's share of clearing is actually occurring at middle and high altitudes. Hence, efforts to improve coffee quality and marketing are targeting areas where most deforestation is occurring and are likely having significant ecological benefits.

1. INTRODUCTION

1.1. Background and objectives

In 2001, after a decade of gradual decline interrupted by short-term spikes, inflation-adjusted world coffee prices dropped to their lowest levels in a half century. The causes of this price shock, commonly referred to as the coffee crisis, included increased production in Vietnam and Brazil, weak demand for low-end coffee, and growing concentration in the roasting sector. Because these factors are structural rather than cyclical, prices are unlikely to rebound dramatically in the short term (Varangis et al. 2003). The coffee crisis has resulted in significant economic hardship in Central America where coffee is a leading agricultural sector. Between 1999 and 2001, Central American export earnings from coffee declined by 45%, while employment fell by about 25% (World Bank 2005a).

In addition to such economic dislocation, the coffee crisis is also having serious adverse environmental impacts. A joint report by the Inter-American Development Bank (IADB), the U.S. Agency for International Development, and the World Bank highlighted three impacts (IADB et al. 2002). First, coffee beans left to rot on abandoned or neglected farms exacerbate plagues and pest infestations. Second, efforts to promote environmentally friendly practices at processing plants have fallen off. Third and most important, the coffee crisis has led to a loss of tree cover and related ecological services. Why?

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1.3. Organization of the report

The report is organized as follows. **Section 2** presents background information on El Salvador's coffee sector. **Section 3** presents information on land cover change in El Salvador's coffee areas between 1990 and 2000, including data from satellite images, interviews with coffee sector stakeholders, and a variety of other primary and secondary sources. **Section 4** provides a brief overview of ongoing and potential policy responses to deforestation in coffee areas. **Section 5** presents an econometric analysis of tree cover change between 1990 and 2000, including a conceptual model of a grower's land use decisions, and a map of predicted probabilities of clearing. **Section 6** concludes the report. It includes a summary of our principal findings, a discussion of their policy implications, and a brief review of directions for future research. The report includes two **appendices**. The first lists the persons interviewed during our trip to El Salvador, and the second describes the computational model used to estimate travel times.

2. EL SALVADOR'S COFFEE SECTOR: BACKGROUND

Coffee was introduced in western parts of what is now El Salvador in the late 1700s and early 1800s and spread rapidly throughout the country beginning in the late 1850s. The Salvadoran government aggressively promoted the new crop by providing growers with land, tax breaks, and seedlings (PROCAFE n.d.). By 1900, coffee was the mainstay of El Salvador's economy.

2.1. Geography

Coffee in El Salvador grows in three main areas: the west region located in the Apaneca-Ilamatapec mountain range; the center region located in the El Balsamo and Chichontepc volcano mountain ranges; and the east region located in the Tecapa Chinameca and Cachuatiqe mountain ranges (Figure 1). According to PROCAFE, in the 2003/04 harvest season, coffee was planted on a total of 161,000 hectares (Table 2.1). Fifty-two percent of this acreage was in the west region, 29% in the center region, and 19% in the east region. More than 45% of El Salvador's coffee acreage lies above 800 meters above sea level (m.s.l.).[7]

Table 2.1. Area planted in coffee by region and altitude
2003/04 harvest season (hectares)

Altitude	West	Center	East	Total
High (1200 m.s.l. plus)	15,834	6,685	2,391	24,910 (15%)
Medium (800–1200 m.s.l.)	22,265	20,429	8,504	51,198 (32%)
Low (> 800 m.s.l.)	45,784	19,179	19,874	84,837 (53%)
Total	83,882 (52%)	46,292 (29%)	30,770 (19%)	160,945 (100%)

2.2. Shade management

Ninety-five percent of El Salvador's coffee is shade grown (GEF 1998). Table 2.2 presents information on the types and prevalence of shade cover.

[7] See the Revised Terms of Reference, October 17, 2005.

Table 2.2. Types and prevalence of shade management

Type	% coffee	Explanation
Rustic to traditional polyculture	5	Rustic: coffee grown in the shade of the natural forest canopy. Traditional polyculture: selected shade tree species interplanted in the natural forest.
Diverse commercial polyculture	20	Shade trees mostly planted, rather than natural. Diversity of trees still relatively high and canopy is high.
Simplified commercial polyculture	30	Lower diversity of trees and density of shade cover; canopy is relatively short and uneven.
Specialized shade	40	A virtual monoculture; shade trees are low-growing, often with considerable gaps between them
Sun	5	Minimum of trees used as windbreaks and for erosion control.

(Source: GEF 1998)

The type of shade cover farmers use depends partly on the local micro-climate. More dense shade cover is used to help retain soil moisture and reduce air temperature in lowland areas which are generally hotter and drier than upland areas. Coffee farms in lowland areas typically have 40% shade cover, while those in highland areas typically have 20% shade cover.

2.3. Production, employment and revenue

In the 2003/04 harvest season, El Salvador produced almost 2 million quintals (46 kg sacks) of green coffee (PROCAFE 2004). This production represented about 1% of the world's total that season and 11% of Central America's total (ICO 2005). Ninety percent of the crop was exported, generating over $120 million in revenue. In the 2003/04 season, the coffee sector employed over 57,000 people permanently and paid over $14 million in wages (PROCAFE 2004).

2.4. Organization

Both production and processing in El Salvador are marked by considerable concentration. The lion's share of Salvadoran coffee growers are small scale. However, the vast majority of land in the sector is held by large growers (Table 2.3). Fifty percent of growers have farms smaller than two hectares, but together these farms comprise less than 5% of all coffee land. Four percent of growers have farms of 70 hectares or more, and together these farms comprise 44% of all coffee land.

Table 2.3. Farm size distribution 2004

Farm size ha.	**Growers** no.	%	**Area** ha.	%
<2	11,708	50	7,762	5
2-7	6,435	27	15,743	10
7-18	2,403	10	17,490	11
18-35	1,266	5	20,790	13
35-70	900	4	29,017	18
70-105	369	2	20,417	13
105+	407	2	49,725	31
Total	23,488	100	160,944	100

(Source: CSC Fondo Emergencia para el Café as reported in PROCAFE 2004)

Three types of growers are found in El Salvador. The most common by far are growers that own and manage independent operations. Such growers sell their coffee to mills that in turn process and export it.

The second type of growers are those affiliated with so-called private cooperatives. They retain full ownership and control of their land, but cooperate with each other in processing and marketing their coffee.[8] According to the Union of Coffee Growers' Cooperatives of El Salvador (*Unión de Cooperativas de Caficultores de El Salvador*–UCAFES), the trade association for private cooperatives, there are a total of 15 private cooperatives comprised of roughly 3,500 growers (about 2% of the total) who control roughly 26,000 hectares (about 16% of the total) and produce roughly 385,000 quintals or green coffee annually (about 15–20% of the total) (Barillas 2006).

The third type of growers are those affiliated with so-called reform cooperatives (*cooperativas de la reforma*) created by the agrarian reforms of the 1980s (see Section 3.2.6 below for a discussion of the reforms). In such cooperatives, most land is held communally. In addition, members are allocated 2–3 hectares of land for their own use. Reform cooperatives are governed by a general assembly overseen by a board of directors. According to PROCAFE's census of coffee producers, in 1998 there were 138 reform cooperatives that controlled 15,400 hectares of coffee land (about 8% of the total) and produced about 200,000 quintals of green coffee (about 9% of the total).

[8] Many of these cooperatives were formed in the early 1980s when coffee marketing was nationalized because cooperatives alone were permitted to market their coffee directly instead of selling it to the National Coffee Institute (*Instituto Nacional de Cafe*–INCAFE), the state coffee marketing organization (Barillas, October 31, 2005).

In El Salvador, coffee processing is performed almost exclusively in large, centralized mills called *beneficios*, not in small on-farm operations which predominate in other Latin American countries. The *beneficios* transform coffee cherries provided by growers into green coffee, an intermediate product, by removing both the pulp and parchment. The *beneficios* then sell the green coffee to exporters. Less than 1% of Salvadoran coffee is roasted prior to export (Table 2.5).

2.5. Export markets

On average, between 1991 and 2003, 88% of Salvadoran coffee was exported (Table 2.4). In 2003/04, the most important markets for Salvadoran coffee exports were—in order of magnitude—the United States, Germany, Belgium, France, Japan, Canada, the United Kingdom, and Italy (Table 2.5).

Table 2.4. Exports by destination for harvest season 2003/04

Destination	Exports (qq green coffee)	Exports (%)	Value (US$)	Value per unit ($/qq green coffee)
United States	729,868.00	41.68	49,587,149.00	67.94
Germany	463,236.00	26.45	30,363,377.00	65.55
Belgium	118,538.00	6.77	8,106,333.00	68.39
France	110,025.00	6.28	7,863,905.00	71.47
Japan	98,834.00	5.64	7,142,331.00	72.27
Canada	80,507.00	4.60	5,683,065.00	70.59
United Kingdom	40,704.00	2.32	2,877,678.00	70.70
Italy	33,743.00	1.93	3,274,062.00	97.03
Other	75,877.00	4.33	5,206,099.00	68.61
Total	1,751,332.00	100.00	120,103,999.00	68.58

(Source: Consejo Salvadoreño del Café as reported in PROCAFE 2004)

2.6. Grades

The Salvadoran Coffee Council (*Consejo de Café*–CSC) assigns coffee one of three quality standards depending on the altitude at which it is grown: central standard (CS) for coffee grown at 600–800 m.s.l.; high grown (HG) for coffee grown at 800-1200 m.s.l.; and strictly high grown (SHG) for coffee grown above 1200 m.s.l. Almost three quarters of Salvadoran coffee exports are either HG or SHG, and another 5% is "gourmet" (Table 2.5). Although other types of specialty coffees have proliferated rapidly in the past several years, they still make up a relatively small share of overall exports. "Organic," "Rainforest Alliance certified," and "Fair Trade" coffees each comprise less than 1% of total exports.

Table 2.5. Grades of coffee exported 2003/04

Grade	(qq green coffee)	(%)	(US $)
CS= Central Standard (Bajío)	67,200.00	3.84	4,294,703.00
HG= High Ground (Media Altura)	804,602.00	45.94	54,331,306.00
SHG= Strictly High Ground (Estricta Altura)	484,777.00	27.68	35,164,074.00
Gourmet	89,727.00	5.12	9,313,643.00
Organic	13,568.00	0.77	1,368,596.00
Rainforest Alliance certified	16,982.00	0.97	1,457,490.00
Fair Trade	3,825.00	0.22	498,825.00
RL (Resaca lavada)	184,140.00	10.51	9,326,889.00
RSL (Resaca sin lavar)	2,250.00	0.13	132,750.00
PV (Pepena verde)	81,263.00	4.64	3,950,463.00
Corriente	1,650.00	0.09	54,409.00
Soluble	555.00	0.03	76,338.00
Roasted	793.00	0.05	134,513.00
Total	1,751,332.00	100.00	120,103,999.00

Note: RL, RSL, PV, and Corriente are inferior grades of coffee.
(Source: Consejo Salvadoreño del Café as reported in PROCAFE 2004)

2.7. Pricing

On average, Salvadoran coffee growers receive 60% of prices paid to exporters and 55% of international prices (Table 2.6). Table 2.5A provides an illustrative example of how producer prices are derived from international prices. The main expenses that account for the difference between the two prices are: $15 per quintal processing costs; $6 per quintal processing losses; and a $6.35 per quintal levy used to pay for the emergency fund, a state sponsored debt restructuring program (discussed in Section 4.2 below) and for technical extension and marketing services provided by PROCAFE and the CSC.

Table 2.5A. Derived producer prices for Salvadoran coffee 2000–2001

Item	US$/quintal	
N.Y. Board of Trade 'C' contract	70.00	
Less differential		3.00
El Salvador coffee F.O.B.	67.00	
Less CSC & PROCAFE levies		1.35
Less emergency fund levy		5.00
Net export price	60.65	
Less processing losses (10%)		6.00
Net revenues	54.65	
Less processing expenses		15.00
Producer price	39.65	

(Source: World Bank 2001)

The farm-gate prices that growers receive are spatially differentiated because they reflect the cost of transporting coffee from the *beneficio* to coffee export ports in the western part of the country (Acahutla in coastal western El Salvador or La Hachadura, St. Tomas, and Puerto Barrios in Guatemala all of which are reached via the Salvadoran border town of San Cristobal.) Hence, coffee growers in the eastern part of the country typically receive lower prices than those in the west, all other things equal.

2.8. Price and climactic shocks during the 1990s

The Salvadoran coffee sector suffered from a series of price and climactic shocks during the 1990s. After a decade of decline in the 1980s, coffee prices rebounded for three harvest years in the mid- to late-1990s (1994/95–1997/98) due in part to a severe freeze in Brazil that reduced world supply, but then continued an overall downward slide in 1998/99 (Table 2.6). Several climactic events also adversely affected Salvadoran coffee production during the 1990s, including severe drought in 1997 associated with an *El Niño* event and hurricane Mitch in 1998 (Varangis et al. 2003; World Bank 2001).

The effects of price and climate shocks on the coffee sector during the 1990s were dramatic. Production, yields, wages, and permanent employment fell by 23–24% between 1991/92 and 2000/01, while exports and export revenue fell by approximately 20%. The reduction in yields reflects the fact that growers cut back on farm maintenance (e.g., pruning) and inputs (e.g., fertilizer) when price shocks hit. The impact of lower prices between 1991/92 and 2003/04 was even more dramatic. Production fell by 38% and yields by 36%. Wages and permanent employment fell by 64%, while exports and export revenue fell by 37%.

According to PROCAFE, between 1991/92 and 2000/01, area planted in coffee only fell by 1%, and it only fell by 2% between 1991/92 and 2003/04. However, these statistics are not based on remote sensing data. As discussed in Section 3, our land cover maps suggest a far more significant loss of shade coffee.

Table 2.6. Coffee prices, area, production, yield, wages, and employment for1991/92–2003/04 harvest years

Harvest year[d]	**Avg. intl. price** (US$/qq green coffee)	**Avg. Salv. price** (US$/qq green coffee)	**Avg. grower price** (US$/qq green coffee)	**Area planted** (ha)	**Production** (qq green coffee)	**Yield** (qq green coffee/ha)	**Person days/ year**[a]	**Permanent employment/ year**	**Exports** (qq green coffee)	**Export revenue** (US$)
1991/92	67.18	58.69	33.14	164,220	3,153,700	19.20	39,421,250	157,685	2,838,195	166,560,475
1992/93	66.30	59.65	35.46	164,220	4,306,200	26.22	53,827,500	215,310	3,901,221	232,724,376
1993/94	119.96	91.19	79.50	164,220	3,403,300	20.72	42,541,250	170,165	2,721,204	248,148,082
1994/95	160.55	164.52	115.64	164,220	3,360,600	20.46	42,007,500	168,030	2,166,831	356,489,940
1995/96	116.91	113.86	76.20	162,190	3,239,100	19.97	40,488,750	161,955	2,948,300	335,683,230
1996/97	174.92	136.22	117.23	162,190	3,305,900	20.38	41,323,750	165,295	3,711,867	505,619,078
1997/98	143.73	154.81	95.91	162,190	3,002,400	18.51	37,530,000	150,120	2,474,448	383,068,013
1998/99	105.19	100.15	59.20	162,226	2,621,900	16.16	32,773,750	131,095	2,388,530	239,220,830
1999/00	100.32	95.56	53.12	162,226	3,712,600	22.89	46,407,500	185,630	3,260,482	311,566,044
2000/01	61.63	58.96	21.08	162,226	2,406,098	14.83	30,075,000	120,300	2,235,188	131,777,208
2001/02	48.62	52.55	18.97	160,945	2,383,076	14.81	23,925,000	95,700	1,997,353	104,951,197
2002/03	62.23	59.62	26.58	160,945	1,963,400	12.20	14,291,200	57,165	1,759,081	104,880,077
2003/04	69.16	68.58	34.06	160,945	1,922,220	11.94	14,344,224[c]	57,377[c]	1,751,332	120,103,999

a. A quintal of green coffee generates 12.5 person days. Includes industrial activities. 2001=10 person days; 2002=7.7 person days; 2003=8.0 person days

b. One employee per year is equivalent to 250 person days.

c. Preliminary 24 September 2004

d. October 1 to September 30

(Source: Consejo Salvadoreño del Café, ABECAFE as reported in PROCAFE 2004)

2.9. Production costs

Understanding coffee production costs helps to make sense of the spatial patterns of land cover change in the 1990s. On average, for the entire country, production costs are about $US 510 per hectare (Table 2.7). In order of magnitude, production costs arise from: harvest (42%); farm inputs (20%); manual labor (19%); administration (13%); financing (3%); and transportation (3%). Per hectare production costs are highest on medium-altitude farms and lowest on low-altitude farms. Per hectare production costs are highest in the east region and lowest in the west region, mainly because both input and transportation costs are higher in the east (PROCAFE 2004).

Table 2.7. Production costs per hectare by altitude range ($US)

Costs	All ($)	All (%)	High (1200 m.s.l. +)	Medium (800-1200 m.s.l.)	Low (<800 m.s.l.)
Direct	428.20	84	242.54	502.77	225.50
Inputs	102.17	20	112.07	155.93	15.46
Manual labor	98.70	19	104.33	124.60	55.80
Harvest	214.50	42	0.00	214.36	152.09
Transport	12.83	3	26.14	7.89	2.16
Indirect	64.39	13	84.83	63.44	38.89
Administrative	64.39	13	84.83	63.44	39.31
Sub-total	492.59	97	327.37	566.21	264.39
Financial (R= 8.35%)	17.01	3	24.24	16.90	11.21
Total	509.60	100	351.61	583.11	275.60

(Source: 1999/2000 PROCAFE survey of production costs as reported in PROCAFE 2004)

2.10. Macroeconomic importance

Historically, coffee has been a mainstay of the Salvadoran macroeconomy. However, its importance has declined dramatically in the past two decades as other sectors of the country's economy have experienced rapid growth and as the coffee sector itself has weathered the coffee crisis (Table 2.8). Coffee's share in gross domestic product (GDP) fell from 7% in 1990 to 2.3% in 2000 to 1.4% in 2003. Its share of agricultural GDP fell from 62% in 1990 to 19% in 2000 to 13% in 2003.

Table 2.8. Contribution of coffee to GDP (million 1990 US$)

Year	GDP	Agricultural GDP	Coffee GDP	Share of Coffee in GDP National (%)	Share of Coffee in GDP Agricultural (%)
1990	5,402.24	605.11	376.00	7.0	62.1
1991	6,288.42	642.24	412.53	6.6	64.2
1992	5,347.72	884.58	243.20	4.5	27.5
1993	5,741.84	861.79	219.75	3.8	25.5
1994	6,089.24	841.32	205.63	3.4	24.4
1995	6,478.64	879.36	203.21	3.1	23.1
1996	6,589.18	890.20	205.96	3.1	23.1
1997	6,868.96	893.55	192.87	2.8	21.6
1998	7,126.53	887.28	176.89	2.5	19.9
1999	7,372.30	955.26	203.86	2.8	21.3
2000	7,531.03	925.26	174.37	2.3	18.8
2001	7,659.75	900.80	150.01	2.0	16.7
2002	7,830.55	902.09	129.17	1.6	14.3
2003	7,974.04	903.05	113.29	1.4	12.5

(Source: El Salvador. BCR, Revistas Trimestrales as reported in PROCAFE 2004)

3. TREE COVER LOSS

This section presents evidence on the magnitude and spatial patterns of tree cover loss in El Salvador's shade coffee regions between 1990 and 2000 as well as the broad socioeconomic and institutional factors affecting this change. It comprises three parts: Section 3.1 presents evidence from satellite images; Section 3.2. discusses the factors affecting tree cover loss; and Section 3.3 presents evidence from expert solicitations.

3.1. Data from satellite images

As discussed in Section 1, to our knowledge, the present effort aside, no hard data have been assembled on the magnitude and spatial pattern of tree cover loss in El Salvador's coffee areas during the coffee crisis. As a result, opinions on the subject vary widely.

We generated tree cover loss data by comparing a 1990 digital land cover map derived from LANDSAT satellite images with a compatible digital map for 2000. The maps were provided by NASA JPL in Pasadena, California.[9] Our tree cover change map has a 57 meter resolution; that is, it is comprised of 57-meter square pixels, or "plots."

We were not able to use more recent land cover maps to generate data on tree cover loss after 2000. Although land cover maps for 2002 do exist, to our knowledge compatible maps for earlier years—that is, maps that were created from the same type of satellite images using the same classification methodology—do not.[10]

The 1990 and 2000 NASA land cover maps do not distinguish between coffee and other types of land cover. Therefore, to identify areas where coffee is growing, we used a Salvadoran Ministry of Agriculture (MAG) land use map for 1992–1994. Derived from 30-meter resolution LANDSAT images, the MAG map includes coffee among its various land use classifications. Figure 1 depicts El Salvador's three main coffee growing areas—the west, center, and east regions—as defined by the land use map. Collectively, these three areas comprise 197,000 hectares. Note that the MAG map only identifies the perimeter of the three main coffee growing areas. It does not distinguish among land uses within the coffee area. Clearly, not all of the land

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[9] Dr. Sassan Saatchi, a Senior Researcher at JPL, supervised the creation of the maps and generously agreed to let us use them for this project.

[10] We relied on existing land cover maps because our project budget did not accommodate creating such maps from scratch.

inside the MAG map coffee perimeters is devoted to coffee. For example, some is devoted to urban uses, pasture, and row crops. According to PROCAFE, in 1993/94, 164,000 hectares, representing 83% of the MAG-defined coffee area, were planted in coffee.

NASA JPL used the following classification scheme to create the 1990 and 2000 land cover maps:

class 0 = water or no class

class 1 = woody vegetation/volcanic soil

class 2 = dense forest

class 3 = mixed woody vegetation (presence of trees)

class 4 = non-forest

Note that a criterion for classes 1, 2, and 3 is the presence of trees. Table 3.1 presents data on land cover derived from the 1990 NASA JPL map, while Figure 2 presents the data graphically. For all three coffee regions, the most prevalent land cover was mixed woody vegetation (63%); followed by dense forest (27%); non-forest (7%); and woody vegetation (2%). The prevalence of each class of land cover does not vary a great deal across the three coffee regions. For example, non-forest areas range from a low of 6% in the west region to 9% in the center region. Both non-forest (9%) and dense forest (29%) were most prevalent in the center region. A comparison of the land cover inside the coffee regions (first column on the left) and outside of the coffee regions (last column on the right) suggests that until 1990, shade coffee may have provided a bulwark against forest cover loss. While 51% of the non-coffee area had no forest cover, only 7% of the coffee regions had none.

Table 3.1. Land cover 1990 by region

Land cover	All coffee regions		West region		Center region		East region		Non-coffee	
	ha.	% region	ha.	% region	ha.	% region	ha.	% region	ha.	% country
Water or no class	710	0	330	0	20	0	360	1	NA	NA
Woody vegetation	4,370	2	700	1	2,550	4	1,130	3	38,210	2
Dense forest	53,020	27	20,950	25	19,830	29	12,240	28	309,610	17
Mixed woody veg.	124,020	63	57,320	68	39,590	58	27,100	61	540,530	30
Nonforest	14,590	7	4,870	6	6,410	9	3,320	8	927,480	51
Total	196,710	100	84,170	100	68,400	100	44,150	100	1,815,120	100

(Source: calculated in ArcGIS from NASA JPL land cover maps)

Table 3.2 presents data on land cover derived from the 2000 NASA JPL map, while Figure 3 presents the data graphically. The data clearly show that considerable forest cover in the coffee regions was lost between 1990 and 2000. For all three coffee regions, land without forest cover increased to from 7% to 17%, while land with dense forest cover fell from 27% to 14%. In this report, we focus on explaining the first type of change.

Table 3.2. Land cover 2000 by region

Land cover	All coffee regions		West region		Center region		East region		Non-coffee	
	ha.	% regions	ha.	% region	ha.	% region	ha.	% region	ha.	% country
Water or no class	710	0	330	0	20	0	360	1	NA	NA
Woody vegetation	2,110	1	260	0	1,680	2	170	0	18,260	1
Dense forest	28,130	14	8,940	11	14,170	21	5,030	11	183,650	10
Mixed woody vegetation	131,440	67	57,630	68	40,390	59	33,410	76	797,300	44
Nonforest	34,320	17	17,010	20	12,130	18	5,180	12	816,610	45
Total	196,710	100	84,170	100	68,390	100	44,150	100	1,815,110	100

(Source: calculated in ArcGIS from NASA JPL land cover maps)

Toward this end, we define a plot as having been "cleared" if it was categorized as "dense forest" (class 2), "woody vegetation" (class 1), or "mixed woody vegetation" (class 3) in 1990 and as "non-forest" (class 4) in 2000. Because each of the first three classes require the presence of trees, we assume that "clearing," as we have defined it, entails tree cover loss. Given this definition, the extent of this tree cover loss clearly varies. For example, the definition includes changes from "dense forest" to "non-forest" as well as changes from "mixed woody vegetation" to "non-forest." Presumably the former changes involve more extensive tree cover loss.

It is important to note that land cover maps based on satellite imagery inevitably involve classification error. For example, "non-forest" pixels may be misclassified as "mixed woody vegetation" and *vice versa.* Therefore, even our rather coarse definition of clearing may be inaccurate. Unfortunately, we do not have data that would enable us to quantify this uncertainty.[11]

Table 3.3 presents data on clearing, while Figure 4 represents it graphically. Fully 13% of land area in the three coffee regions was cleared. The percentage of land cleared differed dramatically across the three coffee regions. It was far and away the highest in the west region (17%) and the lowest in the east region (7%). The percentage of land cleared inside the coffee area (13%) was slightly higher than that outside the coffee area (12%).

Table 3.3. Clearing 1990–2000 by region

Tree cover	All coffee regions		West region		Center region		East region		Non-coffee	
	ha.	% regions	ha.	% region	ha.	% region	ha.	% region	ha.	% country
Cleared	24,700	13	14,000	17	7,500	11	3,200	7	229,100	12
Not cleared	172,100	87	70,200	83	60,900	89	41,000	93	1,742,800	88
Total	196,800	100	84,200	100	68,400	100	44,200	100	1,971,900	100

(Source: calculated in ArcGIS from NASA JPL land cover maps)

Figure 4 shows that clearing was not confined to large uninterrupted areas. Rather, it was highly fragmented and patchy. This pattern begs the question of why some plots were cleared, and others were not, precisely the question that we turn to in Section 5.

Tables 3.4–3.7 present data on clearing by altitude range. Most stakeholders interviewed for this report believed that the lion's share of clearing in El Salvador's coffee areas during the 1990s occurred below 800 m.s.l., where coffee quality, and therefore farm-gate coffee prices, are relatively low. Table 3.4 demonstrates this conventional wisdom is incorrect, however. For the

[11] We restrict our attention to changes from some type of tree cover to a complete lack of vegetative cover as opposed to what might be called "partial clearing"—changes from dense forest to either mixed woody vegetation or woody vegetation—because the later phenomenon is clouded by considerable uncertainty. In addition to the usual classification error, there are at least two problematic issues. First, although we know that partial clearing represents a change from dense forest to less dense forest (either "woody vegetation" or "mixed woody vegetation"), we cannot be certain how significant a change in tree cover is involved. For example, we do not know how much tree cover loss is involved in a switch from "dense forest" to "woody vegetation." By contrast, we know that total clearing entails a shift from some tree cover, however dense, to a complete lack of tree cover. Second, neither stakeholder interviews nor other data provided a clear picture of the processes driving partial clearing. Possibilities included harvesting trees for lumber and firewood, forest fires, intensive pruning, and growing alternative crops. By contrast, we know that total clearing was likely to have involved a change of land uses. Given this uncertainty, we have no clear expectations about, or explanations for, the correlations between partial clearing and the independent variables in our econometric analysis—proxies for, or measures of, the geophysical, institutional, agronomic, and socioeconomic characteristics of the shade coffee regions. As a result, econometric analysis would add little to our understanding of this phenomenon.

entire country, fully 61% of clearing during the 1990s occurred above 800 m.s.l. Forty-six percent of clearing occurred between 800–1200 m.s.l., where coffee is classified as "high grown," and 15% occurred above 1200 meters, where coffee is classified as "strictly high grown."

Table 3.4. Clearing by altitude range 1990–2000 in *all* coffee regions

Range	Area in range		Cleared in 1990		Cleared in 2000		Cleared 1990–2000		
m.s.l.	ha.	% region	ha.	% range	ha.	% range	ha.	% range	% all clearing
0-800	78,200	40	8,680	11	14,890	19	9,440	12	38
801-1200	90,000	46	3,890	4	13,690	15	11,510	13	47
1201+	29,200	15	540	2	3,940	13	3,670	13	15
All	197,400	100	13,100	7	32,510	16	24,620	12	100

(Source: calculated in ArcGIS from NASA JPL land cover maps)

Table 3.5. Clearing by altitude range 1990–2000 in *west* region

Range	Area in range		Cleared in 1990		Cleared in 2000		Cleared 1990–2000		
m.s.l.	ha.	% region	ha.	% range	ha.	% range	ha.	% range	% all clearing
0-800	26,100	31	2,750	11	5,950	23	4,340	17	31
801-1200	40,000	47	1,350	3	7,340	18	6,710	17	48
1201+	18,300	22	170	1	3,030	17	2,930	16	21
All	84,400	100	4,270	5	16,320	19	13,980	17	100

(Source: calculated in ArcGIS from NASA JPL land cover maps)

Table 3.6. Clearing by altitude range 1990–2000 in *center* region

Range	Area in range		Cleared in 1990		Cleared in 2000		Cleared 1990–2000		
m.s.l.	ha.	% region	ha.	% range	ha.	% range	ha.	% range	% all clearing
0-800	31,800	46	3,990	13	5,890	19	3,260	10	44
801-1200	30,500	44	1,690	6	4,860	16	3,680	12	49
1201+	6,300	9	140	2	600	10	510	8	7
All	68,600	100	5,820	8	11,340	17	7,450	11	100

(Source: calculated in ArcGIS from NASA JPL land cover maps)

Table 3.7. Clearing by altitude range 1990–2000 in *east* region

Range	Area in range		Cleared in 1990		Cleared in 2000		Cleared 1990–2000		
m.s.l.	ha.	% region	ha.	% range	ha.	% range	ha.	% range	% all clearing
0-800	20,300	46	1,940	10	3,050	15	1,840	9	58
801-1200	19,500	44	850	4	1,490	8	1,120	6	35
1201+	4,600	10	230	5	310	7	230	5	7
All	44,400	100	3,010	7	4,850	11	3,190	7	100

(Source: calculated in ArcGIS from NASA JPL land cover maps)

The conventional wisdom appears to have reflected the situation in the coffee range prior to 1990, but not after it. Prior in 1990, cleared land as a percentage of total land in each altitude range was almost twice as high below 800 m.s.l. as in the altitude ranges above 800 m.s.l. By 2000, however, these percentages were more or equal in each of the three altitude ranges. Note that the concentration of clearing in higher altitude ranges during the 1990s does not appear to be explained by land scarcity alone. For the entire country, just 11% of land below 800 m.s.l. was cleared in 1990. Therefore, it does not seem likely that clearing shifted from low to high altitudes during the 1990s because most of the land below 800 m.s.l. had already been cleared prior to the 1990s.

There was considerable variation in clearing by altitude range across the three coffee regions. In the west region, 69% of clearing during the 1990s occurred above 800 meters and in the center region, 56% did. In the east region, however, just 42% of clearing occurred above 800 meters.

3.2. Regrowth

Recent research based in part on the same digital land cover maps used for this study has shown that contrary to popular opinion, tree cover in El Salvador actually expanded during the 1990s (Hecht et al. 2005) due to secondary growth on previously cleared land. Indeed, this forest "regrowth" is evident in Table 3.8, which shows that mixed woody vegetation—the land cover category in our land cover maps most likely to capture secondary growth—increased from 541,000 hectares in 1990 to 797,000 hectares in 2000. For the most part, this phenomenon appears to be restricted to areas outside of the coffee range, however. Table 3.8 presents data derived from a woodland regrowth map developed by NASA JPL. Because woodland regrowth is difficult to identify accurately using remote sensing data, the table assigns probabilities to the regrowth classifications. These data suggest that regrowth *may* have occurred on at most 18,000 hectares of land, about 8% of all the land in the coffee range. However, the probability of actual regrowth on 81% of these 18,000 hectares was less than 50%.

Table 3.8. Woodland regrowth 1990–2000 by region and probability range

Regrowth probability	All coffee regions		West region		Center region		East region		Non-coffee	
	ha.	% region	ha.	% region	ha.	% region	ha.	% region	ha.	% country
No change or deforested	177,990	91	79,290	95	62,950	92	35,760	82	1,077,810	59
25-50% prob. regrowth	14,580	7	3,610	4	4,260	6	6,700	15	557,620	31
50-75% prob. regrowth	2,700	1	780	1	880	1	1,040	2	148,200	8
75-100% prob. regrowth	730	0	150	0	290	0	290	1	32,170	2

(Source: calculated in ArcGIS from NASA JPL forest regrowth maps)

3.3. Factors driving tree cover loss in the 1990s

The coffee crisis was an important driver of tree clearing in El Salvador's coffee regions during the 1990s (Table 2.6). Low international prices dramatically reduced the profits in the coffee sector and led to the conversion of coffee acreage to more remuniterative land uses such as housing developments, pasture, and conventional row agriculture. However, the coffee crisis was not the only factor spurring deforestation in coffee areas during the 1990s. Interviews with coffee sector stakeholders, as well as documentary evidence, suggest that a number of complementary factors, including declining yields, debt, poverty, urbanization, war, migration, land reform, and weak regulatory institutions, contributed to, or influenced, the tree cover loss in El Salvador's shade coffee areas during this period.

3.3.1. Downward spiral of on-farm investment and yields

Considerable evidence suggests that the coffee crisis led to a downward spiral of on-farm investment and yields in the coffee sector. The downward spiral began when growers reacted to low prices by cutting back or completely eliminated "discretionary" farm management activities such as pruning and the application of fertilizers and pesticides (World Bank 2001). As Table 2.7 indicates, these activities account for approximately half of per hectare coffee production costs. Although such cost-cutting measures helped to balance cash accounts in the short-term, they also had short- and long-term negative impacts on yields. The reason is that coffee yields depend critically on proper farm maintenance in prior seasons, most importantly pruning coffee plants, shade trees, and secondary growth to allow for the proper amount of sunlight and humidity and to stave off fungus and disease. Hence, inadequate farm management during the first years of the coffee crisis reduced yields in subsequent years. Reduced yields led to even lower profits, and lower profits led to further cutbacks in farm maintenance. Hence, the coffee crisis set in motion a downward spiral of on-farm investment and yields (See Batz et al. 2005 for a bio-economic model of this self-perpetuating phenomenon in a Mexican context).

On some coffee farms in El Salvador, reductions in yields during the coffee crisis were dramatic. For example, managers of a reform cooperative (see Section 3.2.6 for a definition) in the west coffee region reported that since the beginning of the coffee crisis, average production fell 700% from 70,000 quintals on 647 hectares to 8-10,000 quintals as a result of poor farm maintenance (Cooperativas Las Lajas, October 27, 2005). National statistics make clear that this phenomenon has been widespread. On average, yields fell by over 20% from over 19 quintals per hectare in the 1991/92 growing season to about 15 quintals per hectare in the 2000/01 season (Table 2.6).

3.3.2. Debt

Coffee growers in El Salvador depend on annual infusions of working capital. Virtually all credit extended to coffee growers originates with large private banks.[12] Although the banks lend directly to some large coffee growers, they mainly extend credit through intermediaries: cooperatives and the *beneficios* that buy coffee cherries from growers and transform them into green coffee. On average, growers require approximately $40–45 of credit per quintal produced (World Bank 2001).[13] During the 1990s, the coffee sector consumed an average of over $200 million each year, far more than any other agricultural sector (Table 3.9).

Historically, working capital provided to coffee growers was repaid on an annual basis. During the coffee crisis, however, growers' profits were so low that they were unable to repay. Knowing that farmers needed working capital in order to produce enough to make good on their past debts, for several years banks continued to lend despite non-repayment. As a result, the debts owed by coffee growers and *beneficios* mounted. Today, the total outstanding debt of all coffee growers and *beneficios* is estimated at between $200-400 million, an average of $100–210 per quintal or $1,200–2,500 per hectare. As discussed in Section 4 below, the government has taken a number of measures to mitigate this "debt crisis."

[12] Leading banks in the coffee sector are Bancos Agricola, Salvadoreño, Cuscatlan, Hipotecarios, and Fomento Agropecuario.

[13] Of this sum, roughly half is typically used to hire harvest labor and half is used to pay for farm maintenance (Barillas, October 31, 2005; Cooperativa de la Barrio, November 1, 2005).

Table 3.9. Agricultural credit in coffee and other agricultural sectors 1991–2003 (thousands of 2003 $US)

Year	Coffee	Sugar cane	Basic grains	Other ag.	Total ag.
1991	116,730.8	10,580.5	3,110.0	4,721.6	135,142.9
1992	236,171.0	55,326.4	5,453.3	19,696.4	316,647.1
1993	276,283.3	57,098.4	3,221.8	13,604.7	350,208.3
1994	147,446.4	37,641.4	2,101.7	14,413.9	201,603.4
1995	173,724.5	40,743.8	1,803.5	5,952.1	222,223.9
1996	282,731.4	42,605.7	4,982.9	7,645.7	337,965.7
1997	286,300.0	38,500.0	4,300.0	3,600.0	332,700.0
1998	202,200.0	39,400.0	5,500.0	14,700.0	261,800.0
1999	186,000.0	29,200.0	2,700.0	9,900.0	227,800.0
2000P	187,500.0	43,600.0	1,900.0	4,100.0	237,300.0
2001P	184,500.0	31,200.0	1,600.0	2,600.0	219,900.0
2002P	44,800.0	27,400.0	4,000.0	7,400.0	83,600.0
2003P	35,300.0	43,800.0	4,400.0	7,400.0	90,900.0

Notes: P = preliminary
(Source: El Salvador. Banco Central de Reserva, Revistas Trimestrales, 2000-2003, preliminary data in PROCAFE 2004)

Debt contributed to tree cover loss during the 1990s in a number of ways. First, it undermined growers' and *beneficios'* ability to make short- and long-term investments either because banks cut back their annual lending to indebted growers and *beneficios*, or because farm revenues that normally would have been invested were instead devoted to servicing the debt. This lack of investment, in turn, further damaged farm and *beneficio* profits and created incentives for growers to exit the sector. Second, debt led directly to tree cover loss in cases where growers used their land as collateral for loans, and where banks took possession of the land and resold it to construction companies, conventional farmers, ranchers, and others who cleared the land. Third, in some cases, growers sold all or part of their land in order to repay their debts. Finally, as discussed below, indebted growers sometimes sold trees on their land for cash.

Three of the five cooperatives interviewed for this study reported that they were heavily in debt and that all of their profits are allocated to servicing their loans, leaving no funds for investment.[14]

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[14] For example, managers of a small (85 hectare) reform cooperative in the west region stated that they pay $64,000 per year to service their debt and that their creditor has threatened to foreclose unless they are able to repay the outstanding principal (Cooperativa San Rafael Las Nueves, October 27, 2005).[14] Similarly, a large (945 hectare) reform

3.3.3. Poverty

During the 1990s, poverty was pervasive in rural areas of El Salvador, including coffee growing areas. Table 3.10 reports the percentage of Salvadoran households classified as poor and extremely poor in 1991–1992, 1999, and in 2001 after the severe earthquakes of January 2001. At the beginning of the 1990s, 65% of all households in El Salvador, and 66% of households in rural areas, were classified as poor, and 34% of rural households were classified as extremely poor. National poverty rates fell during the 1990s. However, the biggest reductions in poverty levels were in urban areas, not rural ones.[15]

Table 3.10. Percentage of Salvadoran households in poverty

Type poverty	1991–1992	1999	2001*
National	65	48	51
Urban	54	30	40
Rural	66	54	66
Urban extreme	23	9	15
Rural extreme	34	27	36

*Post-earthquake January 2001
(Source: UNDP 2001 as reported in Cuéllar et al. 2002)

Stakeholders interviewed for this report maintain that rural poverty contributes to tree cover loss in coffee growing areas in a number of ways. First, since the onset of the coffee crisis, poor small-scale growers unable to meet their basic subsistence needs from coffee alone have cleared portions of their farms in order to grow maize, beans, and other basic food crops. This phenomenon has been identified as a common response to poverty and income variability among rural households in El Salvador, and a leading cause of tree cover loss in other Mesoamerican shade coffee growing regions (Rodríguez-Meza et al. 2004; Blackman et al. 2005). Second, poor rural households have harvested trees and sold them as lumber and firewood, both of which command a significant per unit price in El Salvador. In some cases, coffee farmers

cooperative in the west region reported that they owe $1.8 million and pay $225,000 each year to service the debt (Cooperative Las Lajas October 27, 2005).

[15] Several factors contributed to the persistence of poverty in rural areas during the 1990s. The agricultural sector in El Salvador—and the coffee sector in particular—were in decline during much of the decade. Especially hard hit were roughly 350,000 landless or land-poor households that depended heavily on agricultural wage labor to meet their subsistence needs (Cuéllar et al 2002). Also, a good deal of the economic growth in El Salvador during the 1990s was due to the expansion of manufacturing and service activities—most notably duty free assembly plants known as *maquilas*—not to progress in the agricultural sector. Poor rural households with limited education and other types of human capital found it difficult to compete for non-agricultural jobs (Rodríguez-Meza et al. 2004; Benkeke de Sanfeliú 2000; López 1997).

harvest the trees themselves. More commonly, however, rural entrepreneurs pay coffee growers for the right to harvest trees on their farms. Finally, in some cases, rural entrepreneurs harvest trees on abandoned or poorly supervised farms without obtaining permission.

3.3.4. Urbanization

With a 2000 population of 6.3 million inhabiting an area of just 21,000 square kilometers, El Salvador has over 315 persons per square kilometer, making it the most densely populated country on the American mainland. By comparison, Guatemala and Honduras have 104 and 58 persons per square kilometer (Cerrutti and Bertoncello 2003).

Not surprisingly given its population density, urbanization in El Salvador is significant. In 2000, 55% of El Salvador's population lived in urban areas, up from 39% in 1970 (Cerrutti and Bertoncello 2003). Land under urban uses grew from 0.8% of the national territory in 1965 to 5% in 1995 (World Bank 1997).

Demand for housing land has grown steadily over the past two decades, particularly since the signing of peace accords in El Salvador in 1992, and particularly in highland areas, (including those used to grow coffee) which have a more hospitable climate than lowland areas. Over the past decade, all manner of farms, including coffee plantations, have been carved up into small lots and sold to construction companies or directly to homesteaders, a process known as "lotification." Lotification does not just cater to middle or upper class Salvadorans. Rather, small lots averaging 250 square meters, with no preexisting buildings, infrastructure, or services are sold at modest prices to low-income households. In 1995, the typical contract for such land was a 10-year mortgage with monthly payments of only 60–70 colones (World Bank 1997).

The burgeoning demand for housing land has driven up land prices. In many areas, the price of agricultural land has risen well above the net present value of its lifetime productive value, making continued agricultural land uses unprofitable (World Bank 1997).

3.3.5. Migration and remittances

A number of factors, including civil unrest and chronic poverty in rural areas, have spurred massive internal and external migration in El Salvador over the past 20 years. Much of the internal migration has been from the eastern and northern parts of the country to the southwestern parts, including the Greater Metropolitan Area of San Salvador (GMASS). This phenomenon, along with population growth, has contributed a dramatic shift in the geographic distribution of El Salvador's population. Between 1971 and 2000, the share of El Salvador's population living in the southwest rose from 53% to 67%. By comparison, the share of the country's population living in the southeast fell from 28% to 20%, and the share of the population living in the north fell from 19% to 13% (Table 3.11). To the extent it has exacerbated population pressures in the southwest, internal migration has contributed to clearing of coffee farms in this area, both for urban and agricultural uses.

Table 3.11. El Salvador population distribution by zones: 1971 and 2000

Zone	**Percent natl. territory**	**Pop. 1971** (millions)	**Pop. 1971** (%)	**Pop. 2000** (millions)	**Pop. 2000** (%)
North	34	0.7	19	0.7	13
Southeast	33	1.0	28	1.2	20
Southwest w/ GMASS*	33	1.9	53	4.1	67
GMASS	3		19		32

*Greater Metropolitan Area of San Salvador
(Source: Cuéllar et al. 2002)

Although internal migration during the 1990s was significant, it paled in comparison to external migration. In 2000, for example, three quarters of rural migration was external, and virtually all of it was to North America (Table 3.12).

Table 3.12. Destination of rural migrants 2000

Destination	**%**
United States and Canada	72
GMASS*	13
Other regions of El Salvador	11
Other countries of Central America	2
Other countries	2

*Greater Metropolitan Area of San Salvador
(Source: Andrade-Edkhoff 2001a as reported in Cuéllar et al. 2002)

The Salvadoran ministry of foreign relations estimates that 2.5 million Salvadorans—roughly a fifth of the total population—now live abroad, and that 90% of these migrants live in the United States (Cuéllar et al. 2002). Table 3.13 presents data on migration to the United States during the 1990s. The total number of migrants to the United States doubled during the 1990s. By 2000, 18% of Salvador's population lived in the United States, three times the percentage in Guatemala, Honduras, and Nicaragua.

Table 3.13. Basic indicators of remittances and migration in Central America

Selected indicators	El Salvador	Guatemala	Honduras	Nicaragua
1999 Remittances ($USD million)	1,580	535	368	345
Remittances as a % of				
Foreign investment	684	364	160	115
Export earnings	64	19	21	63
GDP	13	3	7	14
Population (million)	6.2	10.1	6.3	4.9
Migrants to United States				
1990 census adjusted ('000)	583	279	142	212
2000 census adjusted ('000)	1,118	627	362	294
Annual increment migrants ('000)	53	35	22	8
Annual rate of change (%)	5	6	6	3
Migrants/national population	18	6	6	6

(Source Andrade-Edkhoff 2001b)

Not surprisingly given this massive external migration, remittances have become a critical feature of El Salvador's economy. In 1999, Salvadoran migrants sent home over $1.5 billion, an amount that represented 13% of El Salvador's GDP, 64% of its export earning, and almost 700% of its foreign investment (Table 3.13). Nationally, between 1992/93 and 2000, the percentage of households receiving remittances rose six percentage points from 14% to 20% (Table 3.14). The increase was larger in rural areas (from 13% to 20%) than in urban areas (16% to 19%). The average amount of remittances per household also increased from $76 to $121, the equivalent of the monthly minimum wage (Cuéllar et al. 2002).

Table 3.14. Households (hhs.) receiving remittances

	1992–1993		2000	
	% total hhs.	**Avg. monthly remit/hh.** ($)	**% total hhs.**	**Avg. monthly remit/hh.** ($)
Urban	16	88	19	127
Rural	13	60	20	111
National	14	76	20	121

(Source: Cuéllar et al. 2002)

The percentage of households receiving remittances is highest in the eastern part of the country. The three of the departments with the highest percentages of households receiving remittances are all in the east: La Unión (41%), Morazán (30%), and San Miguel (28%) (Cuéllar et al. 2002). One result of migration has been the proliferation of female-headed households in rural areas. Roughly 30% of rural households in Salvador are run by females (Deere and de Leon in Hecht et al. 2005).

External migration and associated remittances are likely to have had both beneficial and detrimental effects on tree cover in shade coffee regions. On one hand, external migration may have dampened urbanization. Also, remittances may have enabled coffee growing households to continue producing despite low prices and poor credit availability and to avoid clearing trees to harvest the lumber or grow subsistence crops. On the other hand, however, according to stakeholder interviewed for this report, remittances have fueled the demand for urban land uses, and have financed conversion of coffee farms to alternative land uses. In addition, stakeholders report that migration—both external and internal—has created a scarcity of coffee labor in the eastern part of the country.

3.3.6. Land reform

Historically, landholding in El Salvador's agricultural sector was highly concentrated in the hands of a wealthy elite. Mounting political pressure for agrarian land reform, matched by determined resistance to this pressure from the military-controlled government, led to the so called "reformist" military coup of 1979 that made agrarian reform one of its top priorities. Although the three-phase agrarian reform launched by the new military government in 1980 did not succeed in staving off civil war, it did have significant impact on Salvadoran agriculture, including the coffee sector. It was followed by a second land reform program, called the Land Transfer Program (*Programa de Transferencia de Tierras*–PTT), negotiated as part of the peace accords that ended the war in 1992. The PTT mainly distributed land to ex-combatants. Although the details of the various reforms are complex (and outside the purview of this report), the main features were to expropriate land from large-holders and redistribute it to small-holders and cooperatives and to set limits on the maximum size of land holdings. Table 3.15 provides data on the outcome of each reform. Ultimately, the land reforms redistributed over 400,000 hectares—a fifth of the national territory—to over 120,000 beneficiaries.

Table 3.15. Salvadoran land reform programs

Program	Year initiated	Hectares distributed	No. beneficiaries	Hectares per beneficiary
Agrarian reform–Phase I	1980	215,000	37,000	5.8
Agrarian reform–Phase II*	n/a	n/a	n/a	n/a
Agrarian reform–Phase III	1983	80,000	47,000	1.7
Land Transfer Program (PTT)	1992	106,232	36,597	2.9
Total		401,232	120,597	3.3

*Never implemented.

Source: Adapted from Tomaselli and Cuellar (n.d.) using data from the World Bank (1997) and Mejía and Merlos (1999).

The agrarian reforms of the 1980s created so-called reform cooperatives (*cooperativas de la reforma*) in a number of agricultural sectors, including the coffee sector. As discussed in Section 2, in such cooperatives, title to the land is held communally by the cooperative members comprised mainly of those who used to work as agricultural laborers on expropriated land. Reform cooperatives control about 8% of El Salvador's coffee area (PROCAFE 1998).

The consensus view among our stakeholder interviewees was that the creation of reform cooperatives in the coffee sector contributed to tree cover loss in the coffee areas during the 1990s because the cooperatives lacked the management expertise needed to successfully weather the coffee crisis (Gómez, October 25, 2005; Belloso, October 25, 2005; Barillas, October 31, 2005). According to PROCAFE, of the 138 reform cooperatives, about two-thirds are in desperate financial condition (Gómez, October 25, 2005).

Note however, that some documentary evidence concerning reform cooperatives in El Salvador contradicts this conventional wisdom. According to Kay (1998)

> The commonly held view that individual farming is superior to collective farming is not borne out in El Salvador. Yields achieved on the collective land of the producer cooperatives of the reformed sector [in all agricultural sectors, not just coffee] were often higher than yields on family plots either within or outside the reformed sector (Pelupessy, 1995).

Similarly, the World Bank (1997) points out that compared to other forms of land tenure, reform cooperatives have benefits from "more land per capita, better land and more credit..." (31).

3.3.7. Weak land use and land cover management

Both land use and land cover management in El Salvador were weak during the 1990s. Prior to 1998, the main laws governing land use and land cover were the Forestry Law of 1973 and land use permitting laws. The forestry laws required those wishing to clear forest to obtain permits from the Ministry of Agriculture (*Ministerio de Agricultura y Ganaderia*–MAG). In addition, land use planning laws required those wishing to construct buildings to obtain permits from city mayors or the Ministry of Housing and Public Works. In practice, these requirements were frequently ignored. Even when they were not, the criteria for obtaining permits were infrequently enforced and environmental impact assessments were not required (Celis, October 28, 2005; Gómez October 24, 2005; Olano, November 3, 2005). According to a MAG manager, prior to the passage of a new forestry law in 2002, MAG almost never rejected a request for a permit to clear forest.

Environmental management in El Salvador took a major step forward in 1998 with the passage of the Environmental Law (*Ley del Medio Ambiente*) and the creation of the Ministry of the Environment and Natural Resources (*Ministerio de Medio Ambiente y Recursos Naturales*–MARN). By law, MARN is required to issue permits for any changes in land use. According to several government interviewees, however, MARN does not have the resources to conduct a detailed review of permit applications and approves the vast majority submitted.

A key environmental regulatory gap in El Salvador is a system of comprehensive land use planning. Although a law has been drafted, it has yet to be passed. In any case, during the 1990s, no such law existed. As a result, there was a great deal of confusion about which regulatory authority—local mayors' offices of national ministries—had jurisdiction over land use planning permitting (Celis, October 28, 2005).

3.4. Anecdotal evidence

What specific activities were responsible for the clearing in the coffee areas between 1990 and 2000? Row crops? Urbanization? Clearing for lumber and firewood? Unfortunately, no hard data exists to answer this question. Our land cover maps are of little help as they lump all types of land uses that entail clearing into a single class: "non-forest" and give no indication of why land may have been converted from dense to less dense forest. Although a number of approaches could be used to systematically fill this information gap (for example, ground-truthing a sample of plots or using very high resolution remote sensing data, see Section 6.4 for a discussion), they are beyond the scope of this project. Therefore, for the purposes of this report, we rely on evidence from expert solicitations to provide some sense of the factors at play and their relative importance.

Interviews with coffee sector stakeholders (see Appendix 1) suggested that the following activities were the main drivers of clearing in the coffee areas between 1990 and 2000:

- urban uses (e.g., construction of buildings);
- row crops;
- pasture for livestock;
- lumber and firewood (no land use substituted for coffee); and
- accidental forest fires.

Although there was a high degree of consensus among interviewees as to the identity of these drivers, opinions differed on their relative importance, both for the country as a whole and for individual regions. This divergence of opinion is not surprising given the lack of hard data on the issue.

As a first step towards filling this information gap, we administered a questionnaire to the three PROCAFE administrators responsible for PROCAFE operations in the west, center and east regions. Tables 3.16–3.19 present the results. It is important to note that because the data for each region was provided by different respondents, they are not necessarily consistent or comparable.

The survey data suggest that the majority of clearing between 1990 and 2000 in each of the three coffee regions was due to urbanization. According to these data, urbanization played the largest role in clearing in the west region, where it accounted for fully 90% of clearing, and in the center region, where it accounted for 68% of clearing (Table 3.11). Felling trees to harvest lumber or firewood played a significant role in the east region, where it accounted for 20% of clearing. Finally, row crops played a significant, albeit minor, role in each region.

Tables 3.17–3.19 present survey data on the types of coffee farms associated with clearing, a topic that has generated considerable debate. Among the three regions, one notable commonality is that private cooperatives are thought to contribute least to clearing: 0% in both the west and center regions, and 20% in the east region.

Table 3.16. Activities responsible for clearing 1990–2000 by region (%)

Activity	West	Center	East
Urban land uses (e.g., construction of bldgs.)	90	68	50
Row crops	10	5	10
Pasture for livestock			5
Lumber/firewood[a]		5	20
Accidental forest fires		2	5
Others		20	
Total	100	100	100

[a]No land use substituted for coffee
(Source: RFF survey of PROCAFE regional managers)

According to the PROCAFE regional manager, in the west region, all clearing between 1990 and 2000 occurred on independent private farms (versus cooperatives). Over two thirds of urbanization occurred on large private farms, while 30% occurred on small and medium private farms (Table 3.17). Large farms were not mainly responsible for conversion to row crops, however. Sixty percent of this phenomenon occurred on small and medium farms, while 40% occurred on large farms.

Table 3.17. Activities responsible for clearing 1990-2000
in *West* region by type of grower (%)

Activity	Large private farms	Small/med. private farms	Private cooperatives	Reform cooperatives	*Total*
Urban land uses (e.g. const. buildings)	70	30			100
Row crops	40	60			100
Pasture for livestock					
Lumber/firewood[a]					
Accidental forest fires					
Others					
All activities[b]	67	33			100

[a]No land use substituted for coffee; [b]Calculated as weighted average using data for West in Table 3.11.
(Source: RFF survey of PROCAFE regional managers)

The PROCAFE manager of the center region provided information on the percentage of clearing that occurred on different types of farms for all activities (urbanization, row crops, etc.) but not for individual activities. He estimated that half of clearing occurred on small and medium private farms, 30% on large private farms, and 20% on reform cooperatives (Table 3.18).

Table 3.18. Activities responsible for clearing 1990–2000 in *Center* region by type of grower (%)[a]

Activity	Large private farms	Small/med. private farms	Private cooperatives	Reform cooperatives	*Total*
Urban land uses (e.g., const. buildings)					
Row crops					
Pasture for livestock					
Lumber/firewood[a]					
Accidental forest fires					
Others					
All activities	30	50		20	100

[a]Survey responses not provided for individual activities, only for "*All Activities*"; [b]No land use substituted for coffee; -- missing data.

(Source: RFF survey of PROCAFE regional managers)

The PROCAFE manager of the east region painted a particularly complex picture of the activities and types of farms responsible for clearing. He estimated that although urbanization accounted for half of clearing between 1990 and 2000, four other activities, most importantly lumber and firewood collection, also played a significant role (Table 3.19). For each activity, all four types of coffee farms were involved to some degree. On average, for all five activities, large private farms and reform cooperatives were each responsible for 30% of clearing, while small private farms and private cooperatives were responsible for 20%.

Table 3.19. Activities responsible for clearing 1990–2000 in *East* region by type of grower (%)

Activity	Large private farms	Small/med. private farms	Private cooperatives	Reform cooperatives	*Total*
Urban land uses (e.g. const. buildings)	29	17	20	34	100
Row crops	40	15	15	30	100
Pasture for livestock	40	15	15	30	100
Lumber/firewood[a]	20	35	15	30	100
Accidental forest fires	25	20	30	25	100
Others					
All activities[b]	30	20	20	30	100

[a]No land use substituted for coffee; [b]Calculated as weighted average using information provided in Table 3.11.

(Source: RFF survey of PROCAFE regional managers)

4. OVERVIEW OF POLICY RESPONSES AND OPTIONS

This section provides a brief overview of strategies for stemming further tree cover loss in El Salvador's shade coffee regions. The strategies include both those that have already been implemented and those that are under discussion.

4.1. Credit and debt relief

Since 1990, the Salvadoran government has initiated several programs designed to ease coffee growers' debt burden and to provide them with access to credit. Here we review the most important of these initiatives.

Coffee Emergency Fund I (1992). As discussed above, coffee growers depend on annual infusions of working capital from private banks that use *beneficios* as financial intermediaries. As coffee prices dropped in the late 1980s and early 1990s, many growers and *beneficios* were unable to repay annual working capital loans, and as a result, banks became reluctant to extend further credit. This situation made it difficult for growers to generate the revenue required to service their debts. To mitigate the problem, in 1992, the Salvadoran government established a US$45 million line of credit for coffee growers called the Coffee Emergency Fund (*Fondo de Emergencia para la Caficultura*–FEC). It offered growers loans of $15 per quintal regardless of their pre-existing debts, capacity for repayment, or collateral. Borrowers had to repay $4 per quintal per year plus interest for five consecutive years. Funds were obtained through an international loan. The FEC loans have now been repaid (Valiente, October 28, 2005; Varangis et al. 2003)

Coffee Emergency Fund II (2000). In light of adverse market conditions in 1999 created by continued low international prices and a severe drought in 1988, the Salvadoran government provided an $80 million line of emergency credit to coffee growers for the 1999/2000 growing season. Like the first emergency fund, the aim of this program was to enable growers to generate the revenues needed to service their debts. Financed with a bond issue, the program provided growers with $25 per quintal of average production during the previous two seasons. Borrowers had to repay $5 per quintal per year plus 11% interest (later reduced to 7.75%) for five consecutive years. The program was administered by the CSC. The FEC II debts have not yet been fully repaid (Valiente, October 28, 2005; Varangis et al. 2003).

Environmental Trust Fund for Coffee (2001). Recognizing that the debt burden in the coffee sector made default inevitable for many growers, in 2001, the government purchased approximately $250 million of outstanding coffee-related debt from private banks (94% of the total) and restructured it to make repayment easier. The result was the Environmental Trust Fund for Coffee (*Fideicomiso Ambiental del Café*–FICAFE). The term of the debt was extended from four to 20 years with four years of grace (2001–2004) and the interest rate was set at 6.3%. Participating producers were obliged to pay $12 per quintal per year plus interest starting in 2005. Today, 90–95% of all coffee producers participate in FICAFE. FICAFE was the principal component of a broader initiative called The Coffee Rescue Program (*Programa de Rescate Cafetalero*), which provided supplemental credit for production and harvest (Urrutia Loucel 2002; Valiente, October 28, 2005; Varangis et al. 2003; Salazar, November 3, 2005).

Program of Agricultural Guarantees. The Program of Agricultural Guarantees (*Programa de Garantías Agrícolas*–PROGARA) is aimed at ensuring that growers have access to a minimal amount of working capital. PROGARA guarantees private loans to coffee growers of up to $10 per quintal.

Coffee Reactivation Program (2005). In April 2005, the Salvadoran government launched the Program of Financing for the Reactivation of Coffee Farms (*Programa de Financiamiento para la Reactivación Productiva de los Cafetales*) aimed at enhancing productivity and increasing national production to 2.8 million quintals by 2008. Administered by the BMI, the program establishes a $40 million line of credit that provides loans of $475 per *manzana* to be repaid in six years with a two year grace period and a 6% annual interest rate. The loans are provided by private banks but are guaranteed by the Salvadoran government. A condition of the loans is that growers develop a plan to enhance their farm's productivity using technical assistance provided by PROCAFE. The Coffee Reactivation Program is one element of the broader pre-existing Integrated Program for Renovation of Coffee Lands (*Programa Integral de Renovación del Parque Cafetalero*) (Urrutia Loucel, S. 2002; Saca 2005).[16]

Debt relief and debt-for-nature swap. One possible approach to mitigating the debt problem in the coffee sector is to retire the outstanding debt consolidated into FICAFE. The debt could be purchased by the Salvadoran government or an external agent at a considerable discount as expected rates of default over the 20-year term of the restructured loans are significant. However, interviewees pointed out that debt relief is unlikely to be politically practical because

[16] Other initiatives in the program include: a reduction of interest rates on outstanding debts in the coffee sector; investments in improved marketing of Salvadoran coffee in international markets; encouraging coffee farmers to use futures markets to hedge against price risks; and establishing coffee breeding facilities as well as a fund for combating fungus and insects (Urrutia Loucel, S. 2002; Saca 2005).

the coffee sector is already perceived as having benefited from government largess, including the programs detailed above (Valiente October 28, 2005). A second possible approach to the debt problem in the coffee sector is to relieve past debt conditional upon preservation of tree cover. Proposals for such programs are discussed in the next section on payments for environmental services.

4.2. Payments for environmental services

Stakeholders inside and outside of El Salvador have developed proposals for payments for environmental services (PES) systems wherein growers are paid for the environmental services shade coffee provides, and the payments are contingent upon continuing to provide these services.

Asociación Cafetelera et al. proposal (2004). In October 2004, four months after the Saca administration took office, four of the principal coffee trade associations—the Coffee Growers' Association (Asociación Cafetelera), Union of Producer Cooperatives, Mills and Exporters (*Unión de Cooperativas de Productores, Beneficiadores y Exportadore*s–UCAPROBEX), UCAFES, and Salvadoran Association of Mills and Exporters of Coffee (*Asociación Salvadoreña de Beneficiarios y Exportadores de Café*–ABECAFE)—delivered a proposal for a PES system to the office of the president (Asociación Cafetelera et al. n.d. A & B). The proposal suggests creating an Ecological Fund of Payments for Environmental Services (*Fondo Ecológico de Cobro de Servicios Ambientales*–FESA) that would use revenue generated from taxes on three types of utilities that benefit from the ecological services provided by coffee forests: providers of potable water, hydroelectricity, and geothermal electricity. Water utilities operated by the National Aqueduct and Sewerage Administration (*Administracion Nacional de Acueductos y Alcanatarillado*–ANDA) would pay a fee of US$ 0.02 per cubic meter of water, while hydro and geothermal power companies run by the state electricity company (*Comisión Ejecutiva Hidroeléctrica del Río Lempa*–CEL) would pay a fee of US$ 0.012 per Kwh. The revenue collected by FESA would be distributed to three sources. The first would be a newly created institution called the Trust Fund for Sustainable Eco-Coffee (*Fideicomiso EcoCafetalero de Sustentabilidad*–FECS). The government would create FECS by purchasing, restructuring, and guaranteeing private coffee sector debt. The debts would be secured with titles to the growers' land. FESA funds would be used to service growers' debts held by FECS. The second recipient of FESA funds would be coffee growers, who would only receive funds from FESA left over after payments to FECS had been made. Payments to coffee growers—and presumably to FECS—would be conditional on monitoring that showed growers had retained tree cover. The third use for FESA funds would be to promote the reforestation of deforested land, via both the cultivation of coffee forests and of non-coffee forests.

The Asociación Cafetelera et al. (n.d. A & B) estimated that the proposed fees on water and electricity would raise a total of $35.1 million in 2005, comprised of $6 million from water utilities, $17.5 million from hydroelectric providers, and $11.6 million from geothermal electricity providers. Of this, $27.3 million, an average of $140 per *manzana*, would be used to pay FECS. According to several interviewees, the response of the Saca administration to this proposal was negative: new taxes on water and electricity were seen as political non-starters. That said, there may be renewed interest given recent studies of water availability problems (Salaverria, October 31, 2005; Salazar, November 3, 2005).

Pilot PES program (2005). In 2005, the government of El Salvador initiated a $14 million PES pilot program. Funding for the program is being provided by a $5 million loan from the World Bank, a $5 million grant from the Global Environmental Facility (GEF), and $4 million in funds from the government of El Salvador. The program aims to establish pilot PES programs in two to five priority watersheds. The program will pay rural households—mainly hillside farmers—to create or maintain tree cover through agroforestry, reforestation, afforestation, and improved forest management. The payments are to be based upon the value of the ecological services provided by tree cover managed by rural households. MAG is charged with carrying out the studies needed to quantify these ecological services, while MARN is charged with developing a system to make the payments and to monitor tree cover. The formal program has three components. Called "Design and Implementation of a Program of Payments for Environmental Services," the first component will entail designing and setting up a functioning environmental services fund called FONASA, implementing pilot projects in two to five watersheds, and developing procedures to replicate the approach more widely. Called "Institutional Strengthening," the second component of the project will aim to improve the capacity of stakeholders such as national institutions, community associations, and NGOs to participate in the program. The third component of the project is called "Project Management and Monitoring and Evaluation" and will focus on improving project management, monitoring, and evaluation. At this point, it is not clear where revenue for a large-scale program would come from. However, the program's objective is to establish a market-like system in which users of environmental services pay the providers, and the providers are remunerated at no less than their opportunity costs (World Bank 2006; Olano, November 3, 2005; Gómez, October 24, 2005).

Verified Emissions Reductions (proposed). The Multi-sectoral Investment Bank (*Banco Multisectoral de Inversion*–BMI) is currently organizing an effort to generate payments to coffee growers for the carbon sequestration services they provide. Because agricultural sectors such as coffee are not eligible to participate in the Clean Development Mechanism (CDM) of the Kyoto Protocol, the BMI plans to generate these payments by selling Verified Emissions Reductions (VERs) on the voluntary international carbon market. The studies of carbon sequestration, financial and technical feasibility, and social impacts that are needed to obtain certification for the VERs are being conducted by a number of organizations including the Project for Strengthening Environmental Management in El Salvador (*Proyector Fortalecimiento de la Gestión Ambiental en El Salvador*–FORGAES), the Salvadoran Foundation for Economic Development (*Fundación Salvadoreña Para el Desarrollo Económico y Social*–FUSADES), PROCAFE, and the Salvadoran Program for Investigation of Environment and Development (*Programa Salvadoreño de Investigación Sobre Desarollo y Medio Ambiente*–PRISMA). The VERs are expected to sell for approximately $3 per ton and total revenue from the sale is expected to be $2–3 million. This revenue will be paid to growers conditional upon their retention of forest cover (Salazar, November 3, 2005).

Forest Bond Program (proposed). The Forest Bond Program (*Programa Bono Forestal*) is a Salvadoran government afforestation/reforestation program for coffee areas slated to begin operation in 2006. Run by MAG using funds generated by the late 1990s privatization of FANTEL, the government telecommunications company, the program pays coffee growers $120 per hectare to maintain 250 trees per hectare for at least four years. A similar MAG program provides $375 per hectare for planting of 1,000 trees per hectare on non-coffee lands (Gómez, October 27, 2005). One interviewee suggested that afforestation/reforestation could be promoted by providing tax breaks to multinational corporations that invest in coffee plantations on potentially productive lands that have been cleared of tree cover (Salaverria, October 31, 2005).

4.3. Command-and-control: Land use planning and protected areas

As discussed in Section 3.2, to date El Salvador has not implemented a comprehensive national land use planning system. Recently, the Salvadoran government commissioned consultants to develop the framework for such a system and has drafted legislation to implement it. Some interviewees predicted that the legislation will be passed in the first half of 2006. Although this effort represents a major step forward, several interviewees believed that land use plans, like other environmental laws, would mostly be ignored, particularly given that resource-constrained local governments would almost certainly be in charge of monitoring and enforcement (Salaverria, October 31, 2005; Salazar November 3, 2005; Orlano November 3, 2005).

In addition to putting in place a new land use planning system, the Salvadoran government is also planning to strengthen its system of protected areas. Supported by a $5 million grant from the Global Environmental Facility, the project aims to improve the management of protected area, strengthen their institutional and legal framework, test new management strategies in two pilot areas, and improve monitoring and evaluation (World Bank 2005b).

4.4. Coffee quality and certification

Many Salvadoran growers have reacted to the coffee crisis by attempting to move into markets for high-quality coffee, where significant price premiums are available. This shift has been promoted by a wide array of domestic programs, aid agencies, and NGOs. For example, the CSC is spearheading a program designed to develop, certify, and market regional brands of Salvadoran coffee; PROCAFE offers technical assistance in quality control and marketing; and U.S. Agency for International Development funds consultants to provide such technical assistance (Bonilla, November 11, 2005; Karl, November 3, 2005).

Salvadoran growers have also reacted to the coffee crisis by obtaining different types of certification for their coffees, another way of obtaining significant price premiums. A network of government agencies, NGOs, and consultants has promoted this trend. Perhaps most prominent is Salvanatura, a Salvadoran NGO that received multi-year GEF funding in 1998 to promote Rainforest Alliance certification. As discussed in Section 2 above, the most common coffee certifications in El Salvador are Rainforest Alliance, Organic, and Fair Trade (Table 2.5). These and other types of certification proliferated after the onset of the crisis. For example, among the cooperatives interviewed for this study, starting in 1993, Cooperativa San Rafael Las Nueves succeeded in certifying its entire acreage as organic in 2000 (Cooperativa San Rafael las Nueves, October 27, 2005). Similarly, starting in 1996, cooperative Las Lajas succeeded in obtaining either organic or Rainforest Alliance certification for their entire acreage by 2005 (Cooperative Las Lajas October 27, 2005). For the entire country, certification grew from 5,000–7,000 *manzanas* in 1995 to 15,000–20,000 *manzanas* in 2000 (Gómez, October 24, 2005). Because the premium paid for certified coffee is not fixed and depends critically on the quality of the certified coffee, efforts to certify coffee have gone hand-in-hand with efforts to improve quality (Belloso, October 25, 2005).

4.5. Diversification

Promoted by PROCAFE, USAID, and other organizations, one strategy for dealing with the coffee crisis has been to help growers diversify into crops other than coffee. The term "diversification" has been used to refer both to helping growers to cultivate alternative crops, such as vegetables and maize, and to complementing existing coffee with additional agroforestry; for example, substituting fruit trees for shade trees. To the extent it boosts farm income and prevents growers from abandoning shade coffee or switching to alternative land uses, the later strategy is a potential means of preserving tree cover on coffee farms. The former type of diversification can also accomplish this objective to the extent that it utilizes only land that has already been cleared.

4.6. Farm management modifications

An increasingly popular, although little studied, strategy for revitalizing unprofitable coffee farms is to substitute or complement existing managers with external experts. This strategy has been pursued through two avenues. First, according to several interviewees, over the past half decade, some *beneficios* have essentially taken over the management, although not ownership, of farms that owe them significant debts. By improving farm management, the *beneficios* are able to recoup their debts. The owners keep whatever profits remain (Valiente, October 28, 2005).

A similar strategy is being pursued by private sector companies, most notably, Neumann Tropical Farm Management (NTFM), a branch of Neumann Kaffee Gruppe, the world's leading coffee conglomerate. NTFM agrees with coffee growers to takes possession of and manage their coffee farms—typically those that are abandoned and heavily indebted—for a period of ten years. NTFM then uses its management expertise and enormous procurement and marketing advantages to enhance productivity and efficiency. Profits are split between the grower (90%) and NTFM (10%). According to NTFM, the strategy has been very successful. Farms are typically able to turn a profit after one to five years. NTFM currently has 20 such farms comprising 1600 hectares in El Salvador. Evidently, this strategy provides NTFM with entry into the lucrative market for small-farm specialty coffee and allows the company to adhere to Salvadoran land ownership restrictions (Lainez, November 4, 2005).

5. ECONOMETRIC ANALYSIS

This section presents an econometric analysis that aims to identify the factors that explain spatial patterns of tree cover loss between 1990 and 2000, and predict where further tree cover loss is most likely to occur in the future.

5.1. Overview of data assembly

As an aid to understanding the econometric analysis, this section provides a brief overview of the methods used to generate and assemble these data.

Dependent variables. As detailed Section 3 above, we generated data on clearing in the coffee areas by comparing a 1990 digital land cover map derived from LANDSAT satellite images with a compatible digital map for 2000. Figure 4 maps these data.

Independent variables. To explain tree cover change, we collected spatially explicit data on geophysical, institutional, agronomic, and socioeconomic characteristics of El Salvador's shade coffee regions. The data were provided by a variety of sources both inside and outside of El Salvador. In addition to these primary data, we used an ArcGIS model described in Appendix 2 to estimate travel times from coffee farms to the nearest roads as well as travel times from the nearest road to the nearest large city and to coffee export ports (by way of the nearest *beneficio*).

Geographic information system. Using ArcGIS software, we assembled all of the aforementioned information into a single digital GIS system. In essence, the GIS is comprised of dozens of data layers with uniform geographic projections (for example, one layer contains data on soil characteristics, a second contains data on poverty, etc.).

Sample selection. Computational constraints make it difficult to explain tree cover change on each of the 601,000 57-meter pixels, or "plots," in our tree cover map. Therefore, we constructed a sample of plots as follows. We overlaid a 250-meter rectangular grid onto the tree cover change map and selected the approximately 30,000 plots where vertical and horizontal grid lines intersected.[17] Next, we eliminated plots classified as "water" as well as plots for which data are missing. The resulting sample contains 29,450 plots.

[17] Our choice of a 250-meter grid was a compromise between the need for a scale of analysis fine enough to capture the spatial variation in our data set and coarse enough accommodate computational constraints.

For each of these 29,450 sample plots, we used our GIS to match data on tree cover—our dependent variable—with data on the plot's geophysical, institutional, agronomic, and socioeconomic characteristics—our independent variables. Hence, each sample plot comprises one record in our econometric analysis.

5.2. Conceptual model

This section presents a conceptual model meant to underpin our econometric analysis. We start with the assumption that clearing results from a change in land use. We model land use decisions using a conventional "land rent" model (Nelson and Hellerstein 1997; Chomitz and Gray 1996). Following von Thunen, the model is premised on the simple idea that any given plot of land may be devoted to a number of competing uses, each of which earns a rent that depends on the characteristics of the plot (e.g., soil quality and proximity to markets). Land owners devote plots to the uses that generate the highest rents. More formally, the rent an agent receives from devoting plot *i* to land use *k* is given by

$$R_{ik} = P_{ik} Q_{ik} - C_{ik} X_{ik} \tag{1}$$

where R is rent, P is price of output, Q is quantity of output, C is price of inputs, X is quantity of inputs, and

$$Q_{ik} = S_{ik} X_{ik}^{\beta} \qquad \textit{with} \qquad 0 < \beta_k < 1. \tag{2}$$

Thus, the output from plot *i* is determined by a Cobb-Douglass production function where S is a plot-specific shifting parameter. This shifting parameter may be expressed as a product of geophysical and agronomic variables, s_i, having to do with, for example, soil type, slope, and plot size. Equations (1) and (2) imply a rent-maximizing demand for X,

$$X_{ik} = \left(\frac{C_{ik}}{P_{ik} S_{ik} \beta} \right)^{\left(\frac{1}{\beta - 1} \right)}. \tag{3}$$

Furthermore, although spatially differentiated prices are not observed

$$P_{ik} = \exp(\gamma_{0k} + \gamma_{ik} Z_{ik}) \tag{4}$$

$$C_{ik} = \exp(\delta_{0k} + \delta_{ik} Z_{ik}) \tag{5}$$

where Z is a vector of observable location-specific variables such as distance to markets. Substituting equations (3), (4) and (5) into (1), taking logs, simplifying and adding a stochastic error term yields,

$$\ln R_{ik} = \alpha_{ik} + \chi V + u_{ik} \tag{6}$$

where V is a vector of parameters and χ is a vector of plot-specific variables associated with Z and S.

We assume that each plot is devoted to the land use that generates the highest rent. Empirically, we distinguish between two land uses: those such as shade coffee requiring forest cover (k = 0), and those such as agriculture and logging requiring forest clearing (k = 1). Thus, if we define

$$R_i^* = \ln R_{i1} - \ln R_{i0} \tag{7}$$

then plot i will be cleared if $R_i^* > 0$ and will remain forested otherwise. Substituting equation (6) into equation (7) we have

$$R_i^* = \gamma_i - \psi W + u_i \tag{8}$$

where W is a vector of parameters and ψ is a vector of plot-specific variables associated with Z and S. Although R^*_i is latent and unobserved, we observe an indicator variable, L_i such that

$$L_i = 1 \text{ if } R^*_i > 0$$

$$L_i = 0 \text{ if } R^*_i \leq 0.$$

Using this dichotomous dependent variable, equation (8) may be estimated as a probit or logit.

5.3. Data

Table 5.1 presents detailed information on the variables used in the econometric analysis, including units, sources, scale, and dates. The variables are grouped into five categories: tree cover, institutional, geophysical, agronomic, and socioeconomic. Note that although all 20 of the tree cover and geophysical variables are at the plot-level, four of the five institutional, agronomic, and socioeconomic variables are at the canton-level (simply because data at the plot-

Table 5.1. Variables in econometric analysis

Variable	Description	Units	Source	Scale	Years
Tree cover					
CLEAR	plot vegetated in 1990 not vegetated in 2000	0/1	NASA JPL[a]	plot	1990/2000
Geophysical					
CAFE_REGW	located in west coffee region	0/1	ArcGIS	plot	n/a
CAFE_REGC	located in center coffee region	0/1	ArcGIS	plot	n/a
CAFE_REGE	located in east coffee region	0/1	ArcGIS	plot	n/a
TT_RD	travel time from sample point to nearest road	minutes	ArcGIS model	plot	n/a
TT_MK	travel time from nearest road to major coffee ports by way of nearest *beneficio* (w. average)	minutes	ArcGIS model	plot	n/a
TT_CY	travel time to nearest city w/ population >19,000	minutes	ArcGIS model	plot	n/a
AD_0_800	altitude 0–800 meters	0/1	Mapmart Inc.	plot	n/a
AD_8_1200	altitude 801–1200 meters	0/1	Mapmart Inc.	plot	n/a
AD_1200_P	altitude 1200 plus meters	0/1	Mapmart Inc.	plot	n/a
SLOPE	slope		Mapmart Inc.	plot	n/a
N_FACE	aspect is north-facing	0/1	Mapmart Inc.	plot	n/a
SOIL10	effusive andesites and basaltics: pyroclastics	0/1	MARN[b]	plot	n/a
SOIL11	effusive andesites, pyroclastics, volcanic suborded epiclastites	0/1	MARN	plot	n/a
SOIL12	effusive andesites-basaltics	0/1	MARN	plot	n/a
SOIL13	effusive basaltics	0/1	MARN	plot	n/a
SOIL16	effusive basaltics: ashes and lapilli tuffs	0/1	MARN	plot	n/a
SOIL17	volcanic epiclastites, pyroclastics, streams of intercalated lava	0/1	MARN	plot	n/a
SOIL19	acidic pyroclastics (white soil)	0/1	MARN	plot	n/a
SOIL21	acidic pyroclastics, volcanic epiclastites (brown tuffs)	0/1	MARN	plot	n/a
SOIL24	acidic pyroclastics, volcanic epiclastites, ardient and melted tuffs	0/1	MARN	plot	n/a
Institutional					
P_COOP	% of total area planted in coffee managed by reform cooperatives	%	PROCAFE[c]	canton	1998
PROT_AREA	legally protected area	0/1	MARN	plot	1994–1998
Agronomic					
F_SIZE	median area of coffee farms (actually planted in coffee)	ha.	PROCAFE	canton	1998
YIELD	median yield of coffee farms	qu. oro / ha.	PROCAFE	canton	1998
Socioeconomic					
POP_DENS	people per sq. km	n/a	CNR[d]	canton	1992
PERC_WOMEN	% population women	%	CNR	canton	1992

[a]United States National Aeronotics and Space Administration, Jet Propulsion Laboratory; [b] Ministerio de Medio Ambiente y Recursos Naturales; [c]Fundación Salvadoreña para Investigaciones del Café; [d] Centro Nacional de Registros.

level do not exist). There are 950 cantons in the three coffee areas, each averaging roughly 200 hectares, so the resolution of these variables is fairly high. Nevertheless, in interpreting regression results that involve canton-level variables, it is important to keep in mind that they do not reflect the characteristics of the coffee farm on each sample plot. Rather they reflect the average or median characteristics in the canton in which the plot is located.

As discussed below, the causes and characteristics of tree cover loss differ in each of El Salvador's three main coffee growing regions (Figure 1). Therefore, we split the full sample into three regional subsamples. Table 5.2 presents means for the full sample (n = 29,450); the west subsample (n = 13,304); the center subsample (n = 9,519); and the east subsample (n = 6,627). The remainder of this section describes each of the variables in Tables 4.1 and 4.2, and discusses our *a priori* expectation about its correlation with the probability of clearing. In many cases, our independent variables have countervailing impacts on the probability of clearing, and as a result, we do not have strong expectations about their net impacts.

<u>Land use variables</u>

The dependent variable CLEAR equals one if the plot was vegetated in 1990 and cleared in 2000, and equals zero otherwise. The red areas in Figure 4 are those for which CLEAR equals 1. The sample means for CLEAR in Table 5.2 closely mirror the information presented in Section 3 on the magnitude of deforestation in each region.

<u>Geophysical variables</u>

CAFE_REGW, CAFE_REGC, and CAFE_RE. These are dichotomous dummy variables that identify plots located in the west, center, and east coffee regions. In models for the entire country, we use these dummies to control for regional fixed effects. Forty-five percent of our sample plots are in the west region, 32% are in the center region, and 23% are in the east region (Table 5.2).

TT_RD, TT_MK and TT_CY. We use three variables to analyze the effect on the probability of clearing of a plot's location relative to coffee export markets and to the nearest large city. As discussed in Section 5.2, travel times to markets and cities are determinants of farm-gate input and output prices. For example, travel time to coffee export markets affects the price that growers receive for their crop, and travel time to the nearest large city affects the price that they pay for farm labor. Unfortunately, these two travel times are highly correlated because each includes the time it takes to travel from the plot to the nearest road. To minimize this correlation and to disentangle the effects of travel time to coffee markets and travel time to the nearest city, we control for travel time to the nearest road. Hence, we include three travel time variables in the regressions: travel time from the plot to the nearest road (TT_RD); travel time from the nearest road to the nearest coffee export port by way of the nearest *beneficio* (TT_MK); and travel time from the nearest road to the nearest city with a population greater than 19,000 (TT_CY). Appendix 2 describes the ArcGIS model used to estimate travel times.

Table 5.2. Sample means

Variable	**All**	**West**	**Center**	**East**
	(n=29,450)	(n=13,304)	(n=9,519)	(n=6,627)
Tree cover				
CLEAR	0.133	0.176	0.112	0.075
Geophysical				
CAFE_REGW	0.452	--	--	--
CAFE_REGC	0.323	--	--	--
CAFE_REGE	0.225	--	--	--
TT_RD	15.891	15.997	15.938	15.611
TT_MK	191.508	95.217	166.675	420.484
TT_CY	59.853	49.796	55.563	86.203
AD_0_800	0.387	0.301	0.481	0.425
AD_8_1200	0.459	0.479	0.427	0.463
AD_1200_P	0.154	0.219	0.092	0.111
SLOPE	10.901	9.339	11.960	12.517
N_FACE	0.417	0.438	0.377	0.429
SOIL10	0.227	0.184	0.151	0.422
SOIL11	0.034	0.052	0.001	0.046
SOIL12	0.164	0.099	0.249	0.173
SOIL13	0.066	0.131	0.019	0.007
SOIL16	0.013	0.028	0.000	0.000
SOIL17	0.114	0.050	0.282	0.000
SOIL19	0.021	0.000	0.066	0.000
SOIL21	0.302	0.409	0.130	0.337
SOIL24	0.032	0.002	0.092	0.005
Institutional				
P_COOP	5.358	6.903	3.893	4.361
PROT_AREA	0.052	0.026	0.009	0.166
Agronomic				
F_SIZE	14.100	12.771	17.763	11.508
YIELD	13.072	15.405	12.205	9.632
Socioeconomic				
POP_DENS	270.100	261.001	331.935	199.536
PERC_WOMEN	50.304	50.140	50.262	50.692

As discussed in Section 2.7, coffee export markets or international transshipment points are located in the eastern part of El Salvador. Therefore, travel times to coffee markets are far greater in the east coffee region than in the center or west regions. TT_MK averages roughly seven hours in the east region, three hours in the center region, and two hours in the west region. In absolute terms, most travel times in the center and west region are small and probably do not have a very large effect on farm-gate prices. As a result, for many growers, TT_MK may not be an important driver of spatial patterns of clearing. Where it is, however, we expect TT_MK to be positively correlated with the probability of clearing because the growers located far from coffee market towns receive relatively low prices for their coffee and, therefore, earn relatively low rents on coffee farming.

TT_CY has countervailing impacts on the probability of clearing. On one hand, proximity to a relatively large city boosts the return to shade coffee by lowering the transportation and transactions costs involved in acquiring coffee inputs found in cities, notably the labor used to harvest coffee. On the other hand, proximity to a large city also boosts the return to urban and conventional agricultural land uses. The first effect implies that all other things equal, shade coffee—and therefore tree cover—is more likely to be found near big cities. The second effect implies that all other things equal, urban land uses and conventional agriculture—and therefore clearing—is more likely to be found near big cities.

Finally, TT_RD comprises a significant part of total travel times to both coffee markets and cities and, as a result, has countervailing effects on the probability of clearing for the reasons just mentioned.

AD_0_800, AD_8_1200, and AD_1200_P. Altitude (along with slope, aspect, and soil characteristics) can be considered an argument of the production function shift parameter in the land rent model. To control for possible discontinuities in the effect of altitude on the probability of clearing, we constructed six dichotomous altitude dummies. AD_0_800 identifies plots between 0 and 800 meters above sea level (m.s.l.); AD_8_1200 identifies plots between 801 and 1,200 m.s.l., and AD_1200_P identifies plots above 1200 meters. For the entire country, 39% of the sample plots are located below 800 m.s.l. (Table 5.2). However, this proportion in lower in the west (30%), than in the center (48%), or east (43%). In other words, the average sample plots in the west are at a higher altitude than those in the center or east.

Altitude has countervailing impacts on the probability of clearing. On one hand, in the coffee regions—as in most mountain ranges—altitude is highly correlated with both temperature and humidity. Therefore, measures of altitude are essentially proxies for weather conditions. The best grades of coffee grow at higher altitudes, where lower temperatures cause beans to mature more slowly. As a result, coffee farmers at higher altitudes typically get better prices for their crop. By contrast, conventional agriculture is generally less productive at higher altitudes. These factors suggest that altitude will be negatively correlated with the probability of clearing all other things equal. But on the other hand, anecdotal evidence indicates that demand for urban land uses is stronger at higher altitudes because temperature and humidity are lower, an effect that suggests altitude will be positively correlated with the probability of clearing, all other things equal. Which effect dominates is an empirical question.

SLOPE. A continuous variable measured in degrees, SLOPE averages 11 degrees on all sample plots (Table 5.2). On average, SLOPE is higher in the east (13^{o}) than in the center (12^{o}) or west (9^{o}). We expect SLOPE to be negatively correlated with the probability of clearing since the main land uses that substitute for shade coffee—row agriculture urban development—are better suited to flat land.

N_FACE. To capture directional orientation, we use a dummy variable that takes the value of 1 if the plot faces north, and 0 otherwise. In the three main coffee regions, 38–44% of the sample plots are north-facing (Table 5.2). According to PROCAFE, the best grades of coffee grow on south-facing slopes of the three coffee areas that are exposed to humid ocean breezes. As a result, we expect N_FACE to be positively correlated with clearing, all other things equal

SOIL10-SOIL24. Our nine soil type variables—SOIL10, SOIL11, SOIL12, SOIL13, SOIL16, SOIL17, SOIL19, SOIL21, and SOIL24—are dichotomous dummies. Table 5.1 includes a description of each variable.[18] Because many soils that are well-suited to agriculture are also well-suited to coffee, we do not have a strong expectation as to how the soil variables affect the probability of clearing.

<u>Institutional variables</u>

P_COOP. PROCAFE's 1998 census of coffee farms—to our knowledge, the only relatively complete source of farm-level data on the Salvadoran coffee sector—only differentiates between two categories of land tenure: coffee farms managed by the reform cooperatives and all other coffee farms. Unfortunately, the census does not differentiate

[18] The nine dummies in our analysis represent a subset of 25 soil classification categories used by the Salvadoran Ministry of the Environment. Of these 25 categories, we omit 16 because they are either completely absent or very rare in our sample of plots.

between farms that are independently owned and managed, and those that belong to private cooperatives, and to our knowledge such data are not compiled by any other sources including the CSC and UCAFES. Hence, the only land tenure information we are able to include in our model concerns membership in reform cooperatives—we are not able to include information about private cooperatives. Moreover, the 1998 census does not contain geo-spatial data (latitude and longitude) that could be used to identify the land tenure on our sample plots. Therefore, we use it to generate a single canton-level land tenure variable, P_COOP: the percentage of the total area planted in coffee in each canton that is managed by reform cooperatives. P_COOP purports to capture for the likelihood that a given sample plot is managed by a grower who belongs to a reform cooperative. For the entire country, 5% of the coffee area in each canton is managed by reform cooperatives (Table 5.2). However, this percentage ranges from 0–67%. On average, P_COOP is highest in west (7%) and lowest in the center (4%).

We do not have a strong expectation about the effect of P_COOP on the probability of clearing. On one hand, interview evidence suggests that reform cooperatives are both managed by and comprised of the least experienced growers and therefore earn low profits compared to non-reform cooperatives. Based on this logic alone, we would expect P_COOP to be positively correlated with the probability of clearing. But on the other hand, farmers who belong to cooperatives—presumably even those that are poorly managed—may obtain a higher return on their coffee than growers who do not belong to cooperatives. There are three reasons. First, cooperative members generally receive higher prices for their coffee than non-members because cooperatives often control quality better than independent growers and because they tend to have more bargaining power than independent growers. Second, cooperative members typically pay lower prices for inputs than non-members because cooperatives typically subsidize post-harvest processing, quality control, and agricultural extension. Finally, cooperative ownership and control of land may discourage land sales and land use changes. Based on these factors, we would expect P_COOP to be negatively correlated with the probability of clearing. The net effect of the two countervailing effects of P_COOP on the probability of deforestation is an empirical matter.

PROT_AREA. This dichotomous dummy variable indicates whether a plot is located in a "protected" area where clearing is prohibited by law. Our definition of protected areas includes those managed by private organizations, NGOs, and federal, state, and municipal governments. Just 5% of the sample plots in the entire country are located in protected areas. One percent of the plots in the center region are in protected areas and 17% of plots in the east are. We expect PROT_AREA to be negatively correlated with the probability of clearing.

Agronomic variables

F_SIZE. This is a 1998 canton-level variable that purports to capture farm size. It is the median area (in hectares) actually planted in coffee for all of the farms in the canton. We use median farm size instead of the mean farm size to control for extremely large farms in some cantons. The average median farm size for all of the cantons in the entire country is 14 hectares (Table 5.2). Average median farm size is considerably higher in the cantons in the center region (18 hectares) than in those in the west (13 hectares) or the east (12 hectares).

We expect F_SIZE to have countervailing impacts on the probability of clearing. On one hand, the production and marketing of coffee entails significant economies of scale (PROCAFE 2004). Large farms often receive higher prices for their coffee and pay lower prices for inputs such as fertilizers because they tend to have more bargaining power. Based on this logic alone, we would expect F_SIZE to be negatively correlated with the probability of clearing, all other things equal. But on the other hand, small growers enjoy certain cost advantages. Perhaps most important, they are able to rely on low-cost household labor for farm maintenance and harvesting while large farms must use more expensive hired labor. In addition, some of the land uses that compete with shade coffee involve economies of scale, so that they are more profitable on large tracts of land than small ones. For example, anecdotal evidence suggests that builders prefer developing a small number of large coffee farms to developing a large number of small farms. The net effect of the countervailing impacts of F_SIZE on the probability of deforestation is an empirical matter.

YIELD. This 1998 canton-level variable purports to capture farm productivity. It is the median yield (in quintals of green coffee per hectare) of all coffee farms in each canton. Again, we use the median instead of the mean to control for extreme values in some cantons. Average median yield for all cantons in the entire country is 13 quintals per hectares (Table 5.2). However, YIELD varies dramatically across regions. YIELD average 15 quintals per hectare in the west, 12 quintals per hectare in the center, and 10 quintals per hectare in the east.

YIELD has countervailing impacts on the probability of clearing. All other things equal, higher yields are correlated with higher returns to coffee. Based on this logic alone, we would expect YIELD to be negatively correlated with the probability of clearing. However, YIELD proxies for differences in management practices such as the density of tree cover and the intensity of chemical input use. In general, management practices associated with dramatically higher yields also involve dramatically greater per unit production costs. Therefore, the relationship between YIELD on one hand, and the return on coffee and probability of clearing on the other, is complex and we have no strong expectation as to YIELD's sign.

Socioeconomic variables

POP_DENS. The 1992 population density of each canton, POP_DENS averages 270 persons per hectare for the entire country. At the regional level, average POP_DENS ranges from 331 persons per hectare in the center, to 261 persons per hectare in the west, to 200 persons per hectare in the east (Table 5.2).

POP_DENS affects the supply of, and demand for, outputs from different land uses, as well as the supply of, and demand for, agricultural labor, a key input. The effect of population density on the probability of land clearing is difficult to predict *a priori* because it depends on the elasticities of supply and demand for various outputs (e.g., housing and agricultural produce) with respect to population, as well as the elasticities of supply and demand for various inputs (e.g., coffee farm labor) with respect to population.[19] That said, anecdotal evidence suggests that population density has a very strong impact on the demand for—and, therefore, the price and profitability of—urban and agricultural land uses. As a result, we expect POP-DENS to be positively correlated with the probability of clearing.

PERC_WOMEN. This is the percentage of the 1992 population of each canton that is female. The average of PERC_WOMEN is for the entire country, and for the west and center regions is 50% (Table 5.2), while the average for the east region is 51%.

PERC_WOMEN purports to capture outmigration of coffee farmers: presumably, higher values of PERC_WOMEN are correlated with higher rates of outmigration. We expect outmigration to have a variety of countervailing impacts on the probability of deforestation. Outmigration reduces the supply of farm labor, and in doing so, dampens profits for the large-scale growers that rely on it. But outmigration also generates remittances which can be used for a variety of different purposes. For example, remittances could be used support and improve coffee farms, to abandon coffee farms and relocate households to urban areas, to convert coffee

[19] Causation between population and land use may run in the opposite direction as well: people may settle in locations where coffee is productive and relatively profitable. However, we expect that such endgogeneity is negligible in our model as our 1992 population density data largely predate our 1990–2000 land cover data.

farms to different land uses, and to purchase fuel efficient cookstoves that reduce the demand for fuel wood. Thus, the net effect of PERC_WOMEN is an empirical issue.

5.4. Results

Geophysical variables

CAFE_REGW and CAFE_REGC. In Model 1 (all regions), both CAFE_REGW and CAFE_REGC are positive and significant. This result suggests that, all other things equal, clearing was more likely to have occurred in the center and west regions than in the east region.

TT_MK. In Model 1 (all regions) and Model 4 (east region), TT_MK is positive and significant. Hence, for the entire country, and within the east region, we obtain the expected result: plots farther in travel time from coffee export markets were more likely to have been cleared, all other things equal. That we only find this result in the models that include the east region makes intuitive sense. Coffee farms in the center and west are sufficiently close to coffee export markets, which are in the western part of the country, that farm-gate prices are little affected by the costs of transporting coffee to export markets.

TT_CY. This variable is negative and significant in Model 1 (all regions) and Model 3 (center), and is positive and significant in Model 4 (east). Hence, in the country as a whole and in the center region, plots closer to major cities were more likely to have been cleared, all other things equal. This result comports with anecdotal evidence that urbanization is the main driver of clearing in the center region (Table 3.15). In the east, however, clearing is more likely in areas farther from large cities. This result may reflect the fact that a significant share of clearing in the east resulted from harvesting lumber and/or planting subsistence crops by rural households in relatively remote areas where opportunities for off-farm income were limited.

TT_RD. This variable is positive and significant in Model 1 (all regions) and Model 2 (west), and is negative and significant in Model 3 (center). As noted above, TT_RD has countervailing impacts on the probability of clearing.

Table 5.3. Probit regression results
(dependent variable is CLEAR = 1 if plot was vegetated in 1990 and cleared in 2000 and 0 otherwise)

Variable	Model 1 All regions	Model 2 West	Model 3 Center	Model 4 East
	(n=29,450)	(n=13,304)	(n=9,519)	(n=6,627)
Geophysical				
CAFE_REGW	0.62502***	--	--	--
CAFE_REGC	0.262989***	--	--	--
TT_RD	0.00165**	0.00396***	-0.00407***	-0.000621
TT_MK	0.00058**	0.00093	-0.0006	0.00320***
TT_CY	-0.00116**	-0.00077	-0.00176**	0.00251*
AD_8_1200	-0.01224	-0.01393	0.075210*	-0.20926***
AD_1200_P	-0.04937	-0.09332*	-0.00764	-0.28166***
SLOPE	-0.0040**	-0.00158*	0.00026	-0.01153*
N_FACE	0.12758***	0.20894***	-0.11433***	0.26626***
SOIL10	0.06154	0.20749**	-0.27663	0.38868**
SOIL11	0.11918	-0.04381	0.37621	0.07419
SOIL12	0.125210**	0.10522	-0.00869	-0.10595
SOIL13	-0.08700	0.05088	-0.56391**	--
SOIL16	-0.39351***	-0.29345***	--	--
SOIL17	0.09236	-0.02040	0.01820	--
SOIL19	0.03214	--	-0.05690	--
SOIL21	0.06016	0.10701	-0.01610	0.34012*
SOIL24	0.18130**	-0.13581	0.11606	--
Institutional				
P_COOP	-0.00230***	-0.00448***	-0.00101	0.00900***
PROT_AREA	-0.35547***	-0.23911***	0.63384***	-0.64685***
Agronomic				
F_SIZE	0.00022	-0.00043	0.00051*	0.00038
YIELD	0.00156	0.00037	-0.00011	-0.01666
Socioeconomic				
POP_DENS	0.00008***	0.00013***	0.00003*	0.00016
PERC_WOMEN	-0.01881***	-0.02574***	0.00682	-0.02428**
CONSTANT	-0.70864***	0.09491	-1.28227***	-1.75863***
L. Likelihood	-11210.594	-6080.531	-3311.507	-1675.755
Pseudo R2	0.030	0.019	0.018	0.051

-- omitted from model; *** significant at 1% level; ** significant at 5% level; * significant at 10% level

AD_DUMMIES. Although in Model 1 (all regions), neither of the altitude dummies are significant, at least one dummy is significant in each of the regional models. In Model 4 (east), both AD_8_1200 and AD_1200_P are negative and significant; in Model 3 (center) AD_8_1200 is positive and significant; and in Model 2 (west), AD_1200_P is positive and significant. These results echo the discussion of Tables 3.4-3.7: in the east, clearing mainly occurred at low altitudes, but in the center and west it mainly occurred at middle and high altitudes. Taken together, these results comport with the hypothesis that in the east, the lion's share clearing was for row agriculture, which is best suited to low altitudes, while in the center and west, it was mainly due to urbanization, which is increasingly focused on middle- and high-altitude areas with moderate climate.

SLOPE. SLOPE is negative and significant Model 1 (all regions), Model 2 (west), and Model 4 (east). Hence, in the west and east regions, relatively flat land was more likely to have been cleared, a result that comports with our expectations.

N_FACE. As expected, this variable is positive and significant in Model 1 (all regions), Model 2 (west), and Model 4 (east), an indication that in the west and east regions, north-facing plots were more likely to have been cleared, all other things equal. However, N_FACE is negative and significant in Model 3 (center), an indication that in the center region, north-facing plots were less likely to be cleared, all other things equal. We suspect the latter result stems from the historical pattern of urban expansion in the Greater San Salvador Metropolitan Area. For idiosyncratic reasons, urban and agricultural development have been more intense on the south-facing slopes of the El Balsamo mountain range and the Quezaltepec (San Salvador) volcano.

SOIL_DUMMIES. Several of the soil dummies are significant. SOIL 12, SOIL16 and SOIL24 are significant in Model 1 (all regions). SOIL10 and SOIL16 are significant in Model 2 (west region), SOIL13 is significant in Model 3, and SOIL10 and SOIL21 are significant in Model 4 (east region).

<u>Institutional variables</u>

P_COOP. This variable is negative and significant in Model 1 (all regions) and Model 2 (west) and is positive and significant in Model 4 (east). Hence, in the west region, plots that were more likely to have been managed by reform cooperatives were less likely to have been cleared, a result that contradicts the conventional wisdom. In the east region, however, the conventional wisdom does appear to hold.

PROT_AREA. This variable is negative and significant in Model 1 (all regions), Model 2 (west), and model 4 (east). However, it is positive and significant Model 3 (center). Thus, El Salvador's protected areas appear to have been an effective means of stemming deforestation in some, but not all, of El Salvador's coffee growing regions.

Agronomic variables

F_SIZE. F_SIZE is positive and significant in Model 3 (center) and is insignificant in the remaining models. This result suggests that in the center region, large farms were more likely to have been cleared, all other things equal. It comports with anecdotal evidence that clearing in the center region is primarily associated with urban development and that construction companies there prefer to purchase large farms.

YIELD. YIELD is positive and significant in Model 4 (east) and is insignificant in the remaining models. These counter-intuitive results may reflect that fact that, as discussed above, yields are not necessarily positively correlated with profits because high-yield farms also tend to be high-cost farms. They may also reflect measurement error stemming from the fact that our agronomic data are at the canton-level, not the plot-level.

Socioeconomic variables

POP_DENS. As expected, this variable is positive and significant in Model 1 (all regions), Model 2 (west), and Model 3 (center). It is not significant in Model 4 (east). These results, again, comport with anecdotal evidence that urbanization drove deforestation in the west and center, but subsistence agriculture and logging drove it in the east.

PERC_WOMEN. This variable is negative and significant in Model 1 (all regions), Model 2 (west), and Model 4 (east). Thus, cantons in the west and east regions with more women per capita experienced less clearing, all other things equal. To the extent that PERC_WOMEN proxies for remittances, these results suggest that remittances stemmed deforestation.

5.5. Deforestation risk map

We used coefficient estimates from Model 1 (all regions) to predict the probability of clearing on plots that were not already cleared in 2000. Figure 5 presents the results of this exercise graphically. As discussed below, we believe that by pinpointing areas where tree cover loss is most and least likely to occur, these predictions could be of considerable use in targeting policies to stem further tree cover loss in El Salvador's coffee areas. Much of the variation in predicted probabilities is too fine to appear clearly from Figure 5. Several features are immediately apparent, however. For example, predicted probabilities are clearly highest in the west region and lowest in the east region.

6. CONCLUSION

This section has three parts. Section 6.1 summarizes our main findings. Section 6.2 considers their policy implication. Finally, Section 6.3 discusses directions for future research.

6.1. Key findings

The following are the principal findings from our study.

i. Until the 1990s, shade coffee likely provided a bulwark against tree cover loss.

Until the 1990s, a much higher percentage of land inside El Salvador's coffee areas than outside of them retained tree cover. In 1990, 93% of the land inside coffee areas had some type of tree cover, while only 49% of the land outside of these areas did. Hence, historically, coffee appears to have provided a bulwark against tree cover loss in El Salvador.

ii. Tree cover loss in coffee areas during the 1990s was extensive.

During the 1990s, 13% of the land inside El Salvador's three main coffee growing areas was cleared. This percentage was slightly higher than that for land outside of the coffee areas (12%).

iii. Of the three main coffee regions (west, center, and east), the west region experienced the most clearing.

During the 1990s, 17% of the land in the west coffee region was cleared, 11% of the land in the center region was cleared, and 7% of the land in the east region was cleared.

iv. Contrary to conventional wisdom, most clearing in coffee regions during the 1990s occurred in middle- and high-altitude areas, not in lowland areas.

For the entire country, 46% of clearing in coffee areas during the 1990s occurred between 800 meters above sea level (m.s.l.) and 1,200 m.s.l., where coffee is classified as "high grown" and 15% occurred above 1,200 m.s.l., where coffee is classified as "strictly high grown." Only 39% of all clearing occurred below 800 m.s.l.

v. During the 1990s, clearing was fragmented and patchy.

Clearing during the 1990s did not occur in large contiguous areas. The reasons that clearing occurred in some areas and not in others are not immediately obvious.

vi. In addition to declining coffee prices, a complex web of inter-related factors—including a downward spiral of on-farm investment and yields; debt; poverty; urbanization; migration; land reform; and weak land use and land cover regulation—contributed to falling coffee profits and consequent tree cover loss in the 1990s.

In a broad sense, clearing in coffee areas during the 1990s can be attributed to a sharp decline in profits from coffee farming relative to profits from other land uses such as housing, row agriculture, and livestock. Although low coffee prices were undoubtedly an important factor driving this phenomenon, an array of intertwined factors contributed to it. These included:

- a *downward spiral of on-farm investment and yields* touched off when low prices led growers to cut back on "discretionary" farm management and investment, which depressed yields, which further depressed profits, which resulted in more cuts in management and investment;

- mounting *debt* that: (a) dampened short- and long-term investment in the coffee sector either because banks cut lending to indebted borrowers, or because retained earnings that normally would have been invested were instead devoted to servicing debt; (b) led directly to tree cover loss in cases where banks foreclosed on land used as collateral and resold it to developers, ranchers, and farmers; and (c) created incentives for growers to sell their land or the trees on it to repay their debts;

- *poverty* that led: (a) small-scale growers unable to meet their basic needs from coffee alone to clear portions of their farms in order to grow subsistence crops; and (b) rural households to harvest trees and sell them as lumber and firewood;

- *urbanization* that raised the return on converting coffee land to housing developments and other urban uses;

- *migration*, especially from the eastern parts of the country, that fueled urbanization by: (a) generating remittances used to purchase houses (when migration was external); and (b) increasing population density in the center and west parts of the country (when migration was internal);

• *land reform* that, notwithstanding important social benefits, led to the creation of a class of new growers with limited management experience; and

• *weak land use and land cover regulation*.

vii. Although hard evidence on the exact land uses changes that led to tree cover loss is lacking, PROCAFE regional managers estimate that urbanization was responsible for 50–90% of clearing in each coffee region during the 1990s.

PROCAFE managers estimate that urbanization was responsible for 90% of clearing in the west region, 70% in the center region, and 50% in the east region. Among other land uses substituted for coffee during the 1990s, row crops were thought to be responsible for 5–10% of clearing in each region, while harvesting lumber and firewood were thought to be responsible for 20% of clearing in the east region.

viii. An array of policies and programs that have the potential to help slow tree cover loss in shade coffee areas are ongoing, planned, or under discussion. However, for the most part, these efforts ignore spatial differences in the risk of further tree cover loss. Ongoing initiatives include:

• subsidized credit and debt relief for coffee growers;

• payments for environmental services programs that would provide financial incentives for coffee growers to retain tree cover;

• command-and-control measures including new land use planning legislation and improved protected areas management; and

• programs to help growers improve coffee quality and marketing; diversify into alternative tree crops; and improve farm management.

ix. The probability that any given plot in El Salvador's coffee areas was cleared during the 1990s depended upon its geophysical, institutional, agronomic, and socioeconomic characteristics in ways that were complex, differed across the three coffee regions, and often contradicted conventional wisdom. This complexity reflects the fact that a variety of very different land uses were displacing coffee during the 1990s. All other things equal, clearing was more likely to have occurred on plots:

• *in the west and center* coffee regions;

• *farther from coffee export markets* (the two cities from which all Salvadoran coffee is exported) in the east region;

- *close to major cities* in the center region but far from major cities in the east region;
- *at high altitudes* (above 800 m.s.l.) in the center and west regions, but at low altitudes in the east region;
- that were *relatively flat* in the west and east regions;
- that were *north-facing* in the west and east regions;
- in cantons where an above-average share of land was held by *reform cooperatives* in the east region, but in cantons where a below-average share of land was held by reform cooperatives in the west region;
- that were outside the boundaries of a *legally protected area* in the west and east regions, but that were inside such areas in the center region;
- in cantons that had a relatively high percentage of *large farms* in the center region;
- in cantons that were relatively *densely populated* in the center and west regions; and
- in cantons that had a relatively low percentage of *female headed households* (a proxy for *migration and remittances*) in the east and west regions.

Three general comments about these results are in order. First, several defy conventional wisdom and shed light on contested issues. Conventional wisdom holds that during the 1990s, clearing mainly occurred in lowland areas that produce inferior quality (generally less profitable) coffee and that reform cooperatives were responsible for a disproportionate percentage of clearing. However, we found clearing was more likely at high altitudes in the west and center regions and in areas where a below-average share of land was held by reform cooperatives in the west coffee region. The effects of farm size and remittances on clearing have been the subjects of considerable debate. Our results suggest that large farms were responsible for a disproportionate share of clearing in the center region, and that remittances discouraged clearing in the west and east regions.

Second, a consistent underlying story would appear to explain many of the difference in econometric results across regions: urbanization drove deforestation in the west and center, while subsistence agriculture and logging were important in the east. Specifically, we found that in the west and/or center regions, clearing was positively correlated with population density, proximity to major cities, large farm size and higher altitudes (large farms at higher altitudes are the preferred targets of developers). In the east region, by contrast, we found that clearing was negatively correlated with proximity to major cities and with higher altitudes (row agriculture is better suited to low altitudes). This underlying story comports with anecdotal evidence provided by PROCAFE about the relative importance of clearing in the west and center versus the east regions.

Finally, our results provide additional support for the hypothesis proposed by Blackman et al. (2004) that in shade coffee regions, clearing is more likely to occur far from major markets, the opposite of the pattern in natural forests.

6.2. Policy prescriptions

i. A rapid policy response is needed.

Although historically, shade coffee appears to have provided a bulwark against deforestation, this no longer appears to be the case. During the 1990s, tree cover in shade coffee areas was lost at a rapid rate and there is ample reason to suspect that this trend has continued apace given that coffee prices reached a 50-year low in 2001 and have remained well below $1 per pound since then. To preserve what tree cover remains, and to prevent soil erosion, flooding, biodiversity loss, and other types of environmental degradation that would result from further deforestation, action must be taken quickly. Moreover, because the coffee crisis has set in motion the downward spiral of on-farm investment and yields, the problem is only likely to become more difficult to address with the passage of time.

ii. Policies and programs to conserve tree cover in shade coffee areas must be carefully targeted and tailored.

Policy responses need to be carefully targeted and tailored to specific locations and institutional settings. Our results indicate that the drivers and characteristics of clearing differ across the three coffee regions. For example, clearing in the east was more likely to have occurred in lowland areas far from cities and markets, a finding that suggest it was driven in large part by logging and subsistence agriculture. In the center and west, by contrast, clearing was more likely to have occurred in densely populated highland areas in close proximity to cities, a finding that suggest it was driven mainly by urbanization. Given such heterogeneity, one-size-fits-all approaches are almost certain to be ineffective and inefficient. For example, a policy that only targeted coffee farms in lowland areas would not address the bulk of tree cover loss, which is occurring in the center and west highland areas, and a policy that only targeted coffee farms in close proximity to cities would miss clearing that is occurring in rural areas in the east region. The "deforestation pressure" map described in Section 5.6 could be an ideal tool for targeting forest conservation policies.

iii. Command-and-control policies are needed to stem tree cover loss due to urbanization but are not likely to be effective in the short- to medium-term.

Our research suggests that urbanization, along with a host of intertwined factors (including speculation and an inflow of financial capital from remittances), have dramatically inflated land prices in coffee areas, thereby creating strong incentives for coffee growers to earn windfall profits by selling their farms to developers. Furthermore, this phenomenon appears to be a key driver of land use change in some coffee areas. In such areas, market-based forest conservation approaches, such as payments for environmental services (PES) and coffee certification programs, are not likely to be effective when used in isolation; that is, absent complementary command-and-control policies. In areas where land prices and urbanization are driving land use changes, it is hard to imagine PES or certification programs that could provide financial incentives on par with the land market.

The alternative to market-based incentives is conventional command-and-control land use and land cover regulation.[20] In our view, such regulation is absolutely necessary to control tree cover loss in El Salvador's coffee areas where urbanization is driving land use changes. Unfortunately, however, it is not likely to be effective in the short- to medium-term. To date, by all accounts, land use and land cover regulation in El Salvador has proven toothless. Regulatory authorities apparently lack the institutional capacity and political will to counter the powerful economic and political forces driving urbanization and other types of land use change. New national land use planning legislation is reportedly imminent. However, building the institutional capacity to implement it will take some time. Absent a dramatic shift in policy or market conditions, there is little reason to be optimistic that tree cover loss due to urbanization in coffee areas can be reversed in the next five years.

Having said this, three strategies may help to slow this phenomenon. One is to create incentives for land developers to clear and build in a manner that minimizes environmental degradation by, for example, retaining as much tree cover as possible, avoiding ecologically sensitive areas, and retaining corridors between forested areas. A second strategy is to combine market-based incentives and command-and-control policies, as hybrid policies may prove more

[20] Another option is to levy taxes on urban development in shade coffee areas that are sufficiently high as to deter all but the most profitable land use changes.

effective than one-dimensional policies. Finally, policymakers can ensure that coffee growers who have the potential to turn a profit under current market conditions have access to credit as well as a feasible strategy for making good on past debts. Presumably, growers who lack access to working capital and those who see no way to climb out from under their financial obligations are most liable to trade a stream of future income from coffee for a one-time windfall profit from the sale of land. However, credit market interventions—and, in particular, conventional debt relief—are only advisable if they can be structured in a manner that all but eliminates perverse incentives for non-repayment and regressive distributional impacts.

iv. Encourage efforts to improve coffee quality and marketing.

One of the most promising recent developments in the Salvadoran coffee sector has been the success of efforts to improve coffee quality and marketing, particularly in highland areas that are well-suited to producing high-end coffee. By enabling growers to access a more remuniterative segment of the coffee market, these efforts are generating substantial economic benefits. But what effect are they having on deforestation?

Conventional wisdom holds that the lion's share of deforestation in shade coffee areas is occurring at low altitudes. The implication is that efforts to improve coffee quality and marketing in highland areas miss the mark in terms of ecological benefits. Our results suggest the opposite, however. We find that in the center and west regions, the lion's share of clearing is actually occurring at middle and high altitudes. Hence, efforts to improve coffee quality and marketing are targeting areas where most deforestation is occurring and are likely having significant ecological benefits.

6.3. Directions for future research

Future research on tree cover loss in El Salvador's coffee areas falls into two categories: refinements and extensions. As for the former, a priority will be to test and, if necessary, correct for spatial autocorrelation in our regression models. If corrections are needed, we will use Bayesian heteroskedastic spatial autoregressive procedure for logit (LeSage 2000; Blackman et al. 2003).

We envision three possible extensions. First, we hope to update the analysis to assess tree cover changes during the past five years. We would: use 2001 and 2006 LANDSAT satellite images to develop a new tree cover change map; update our socioeconomic explanatory variables; and run regressions to explain tree cover changes during this period. This effort will enable us to determine whether and how land clearing during the past five years has differed from that described in this report. Moreover, it will enable us to develop a more accurate "deforestation pressure" map of the predicted probability of future deforestation that can be used to spatially target efforts to stem the loss of shade coffee.

Second, if there is sufficient interest among policymakers, we may develop a land *use* change map for 2001–2006. That is, we would develop a fine-scale map that identifies the specific land uses (e.g., housing developments, pasture, and row crops) being substituted for shade coffee. Such a map would help policymakers design and target policies to stem tree cover loss. For example, it would enable policymakers to pinpoint areas where urbanization is driving deforestation and where, as a result, PES is not likely to be effective unless complemented by other policies. Preliminary investigation suggests that the most cost-effective means of creating such a map would be to supplement 2001 and 2006 LANDSAT satellite images with ultra-high-resolution SPOT or IKONOS images for selected portions in our study area. Along with limited "ground-truthing" (i.e., visual inspection by field agents), the ultra-high-resolution images would enable us to develop computerized classification routines that reliably differentiate among cleared land uses.

Finally, and most important, we would like to combine deforestation pressure maps with two other types of data that policymakers need to target forest conservation policies: (i) spatially explicit information on the benefits of forest conservation (i.e., the monetary value of carbon sequestration, soil conservation, etc.); and (ii) spatially explicit information on the costs of forest conservation (i.e., the cost of a PES system). More technically, we would develop estimates of the expected net-benefits of preserving forest cover on a sample of plots inside the coffee range. The expected net benefit of forest conservation on any given plot can be given by (P*B – C) where P is the probability of clearing on the plot absent an intervention; B is the value of the ecological services generated by forest cover; and C the cost of the forest conservation intervention. It is necessary to discount the ecological benefits of forest conservation effort, B, using the probability of clearing absent an intervention, P, to take into account the fact that an intervention that preserves tree cover on a plot that is not likely to be cleared provides no real benefits. Our deforestation pressure map provides the best measure of P. The envisioned extension, then, would be to develop plot-level estimates for B and C. We would develop estimates of B in collaboration with ecologists, most likely focusing primarily on watershed and/or carbon sequestration benefits. (For an application of this approach to Costa Rica, see Pfaff and Sanchez-Azofeifa 2004).

REFERENCES

Asociación Cafetelera, UCRPORBEX, UCAFES and ABECAFE. No Date A "Fondo Ecológico de Cobro de Servicios Ambientales."

Asociación Cafetelera, UCRPORBEX, UCAFES and ABECAFE. No Date B. "La Caficultura, Una Garantia de Sostenibilidad Ambiental par Nuestras Futuras Generaciones."

Andrade-Eekhoff, K. 2001a. Mitos y realidades: Un análysis de la migración en las zonas rurales de El Salvador. Presented that the Latin American Studies Association Annual Meetings.

Andrade-Eekhoff, K. 2001b. Intercambios transnacionales a través de las migración en Centroamérica: Dimámicas, impactos y potencial. Power point presentation. Facultad LatinoAmericana de Ciencias Sociales (FLASCO): San Salvador.

Barillas, F. 2006. President Unión de Cooperativas de Caficultores de El Salvador (UCAFES). Email to Allen Blackman. January 25.

Beneke de Sanfeliú, M. 2000. Dinámica del ingreso de las familias rurales in El Salvador. Estudio de Panel 1995-1997. Documento de Investigación BASIS no. 1. Fundación Salvadoreño para el Desarrollo Económic y Social, San Salvador.

Batz, M., H. Albers, B. Avalos-Sartorio, and A. Blackman. 2005. "Shade-Grown Coffee: Simulation and Policy Analysis for Coastal Oaxaca, Mexico." *RFF Discussion Paper 05-61.* Available at: www.rff.org

Blackman, A., H. J. Albers, B. Ávalos, and L. Crooks. 2005. "Deforestation and Shade coffee in Oaxaca, Mexico: Key Research Findings," *Resources for the Future Discussion Paper 05-39.* Available at: www.rff.org

Blackman, A. H. J. Albers, B. Ávalos, and L. Crooks. 2003. "Land Cover in a Managed Forest Ecosystem: Mexican Shade Coffee." *Resources for the Future Discussion Paper 03-60.* Available at: www.rff.org

Cerrutti, M., and R. Bertoncello. 2003. Urbanization and Internal Migration Patterns in Latin America. Centro de Estudios de Población. Argentina.

Cuéllar, N. I. Gómez, S. Kandel, and H. Rosa. 2002. Rural Poverty and the Environment in El Salvador: Lessons for Sustainable Livelihoods. Programa Salvadoreño de Investigación Sobre Desarollo y Medio Ambiente (PRISMA): San Salvador.

Deere, C., and M. León. 2000. Genero, propiedad y emproderamiento: tierra, estado y mercado en América Latina. Bogotá: Tercer Muncio Editores.

FAO Forestry Department. 2002. El Salvador: The forests and the forestry sector. Available at www.fao.org/forestry/site/23747/en/slv.

Global Environmental Facility. 1998. "El Salvador: Promotion of Biodiversity Conservation within Coffee Landscapes." Mimeo.

Hecht, S. H. Rosa, and S. Kandel. 2005. Globalization, Forest Resurgence, and Environmental Politics in El Salvador. *World Development* 34(2): 308–323.

Inter-American Development Bank, US Agency for International Development, and World Bank. 2002. "Managing the competitive transition of the coffee sector in Central America." Paper prepared for Workshop on the Coffee Crisis and its Impact in Central America: Situation and Lines of Action. Antigua, Guatemala, April 3–5.

International Coffee Organization (ICO). 2006. Coffee statistics. Available at: www.ico.org.

Kay, C. 1998. Latin America's agrarian reform: Lights and shadows. *Land Reform, Land Settlement and Cooperatives*, Rural Development Division, Food and Agriculture Organization: Rome.

López, R. 1997. Rural poverty in El Salvador: A quantitative analysis. Report 16253-ES, World Bank: Washington, DC.

Mejía, E., and Merlos, E. 1999. Análisis del uso del suelo en las unidades productivas del PTT. Estudio de caso. San Salvador: FUNDE.

Gresser, C., and S. Tickell. 2002. "Mugged: Poverty in your coffee cup." Oxfam: London.

Perfecto, I., R. Rice, R. Greenberg, and M. E. Van der Voort. 1996. "Shade coffee: A disappearing refuge for biodiversity." *Bioscience* 46(8): 98–608.

Pfaff, A., and G. A. Sanchez-Azofeifa. 2004. Deforestation pressure and biological reserve planning: a conceptual approach and an illustrative application for Costa Rica. *Resource and Energy Economics* 26: 237–254.

Ponte, S. 2002. "The Coffee Crisis." Issue Paper. Center for Development Research: Copenhagen.

Pelupessy, W. 1995. *Agrarian transformation and economic adjustment in El Salvador, 1960-1990*. Unpublished Ph.D. dissertation. Katholieke Universiteit Brabant: Tilburg.

PROCAFE (Fundación Salvadoreña para Investigaciones del Cafe). n.d. "El Salvador: Land of Coffee." PROCAFE: San Salvador.

PROCAFE (Fundación Salvadoreña para Investigaciones del Cafe). 1998. Census of coffee growers. PROCAFE: San Salvador.

PROCAFE (Fundación Salvadoreña para Investigaciones del Cafe). 2004. "Boletín Estadístico de la Caficultura Salvadoreña." PROCAFE: San Salvador.

Rice, R. 2003. Coffee Production in a Time of Crisis: Social and Environmental Connections. *SAIS Review* 23(1): 221-245.

Rodríguez-Meza, J. D. Southgate, and C. González-Vega. 2004. Rural poverty, households responses to shocks, and agricultural land use: Panel results for El Salvador. *Environment and Development Economics* 9: 225–239.

Saca, El. A. 2005. Transcriptio of April 4 speech on "Lanzamiento del Programa Integral de Renovación". Available at http://www.procafe.com.sv/docs/discursopresidencial.doc

United National Development Programme (UNDP). 2001. Informe Sobre Desarrollo Humano El Salvador 2001. San Salvador.

Urrutia Loucel, S. 2002. Presentation on the situation in El Salvador at "Taller Regional "La Crisis Cafetalera y su Impacto en Centroamérica: Situatción y Lineas de Acción," Antigua Guatemala, April 4–5.

Varangis, P., P. Siegel, D. Giovannucci, and B. Lewin. 2003. "Dealing with the Coffee Crisis in Central America: Impacts and Strategies." Policy Research Working Paper 2993. The World Bank Development Research Group. March.

World Bank. 1997. El Salvador Rural Development Study, Main Report, Volume I. Report No. 16253-ES, August. Washington, DC.

World Bank 2001. El Salvador: Coffee Price Risk Management. Phase 2 Report. August. Washington, DC.

World Bank. 2005a. Shocks and Social Protection: Lessons from the Central American Coffee Crisis. Report No. 31857-CA. Washington, DC.

World Bank. 2005b. El Salvador Protected Areas Consolidation and Administration Project. Report No.: 33759-SV. Washington, DC.

World Bank. 2006. "El Salvador Environmental Services Project." Available at http://www-wds.worldbank.org

APPENDIX 1. STAKEHOLDER INTERVIEWS, EL SALVADOR, OCTOBER 24–NOVEMBER 4

Monday, October 24

1. Fundación Salvadoreña para Investigaciones del Cafe (PROCAFE), San Salvador

Oscar Gómez

Carlos Pleitez

Magdil Salazar

Sergio Gil

Board of Directors

Tuesday, October 25

2. InterAmerican Development Bank (IDB), San Salvador

Sybille Nuenninghoff, Sectoral Specialist

3. Direción General de Estatitica y Censos (DIGETYC), San Salvador

Angel Corleto Urey, Director General

4. Programa Salvadoreño de Investigación Sobre Desarollo y Medio Ambiente (PRISMA), San Salvador

Herman Rosa, Director

5. Salvanatura, San Salvador

Guillermo Enrique Belloso, Director, Certification and Agricultural Sustainability Program

Wednesday, October 26

6. Boqueron Cooperative (private), center coffee region

Maria Cristin Urrutia, President

7. Santa Adelaida Cooperative (reform), center coffee region

Jorge Rumaldo Mejía

Rafael Melgar Mejía

Thursday, October 27

8. Las Lajas Cooperative (reform), west coffee region

Francisco Hernandez, President

Pedro Grandos, Manager

9. San Rafael las Nueves Cooperative (reform), west coffee region

Manfrey Chavez, President of Production and Surveillance

Tito Hernandez, Statistical control

Angel Lima, Treasurer

Jorge Represaz, Secretary

Friday, October 28

10. Asociacion Salvadoreña de Beneficiadores y Exportadores de Café (ABECAFE)

Miguel Valiente, President

11. Proyector Fortalecimiento de la Gestión Ambiental en El Salvador (FORGAES)

Luis Arturo Celis, Co-Country Director

Monday, October 31

12. Minsterio Agricultura y Gandaria (MAG), San Salvador

Jorge Armando Alabi, Director General, Direcion General de Economia Agropecuaria

13. Fundación Salvadoreña para Investigaciones del Cafe (PROCAFE), San Salvador

Gregorio Tenorio, Manager west region

Salvador Flores, Manager center region

Walter Iglesias, Manager east region

14. Comisionado Presidencial, Promocion y Negociación de Café, San Salvador

    José Antonio Salaverria Borja

15. Unión de Cooperativas de Caficultores de El Salvador (UCAFES), San Salvador

    Federico Barillas, President

Tuesday, November 1

16. Ciudad Barrios Cooperative (private), east coffee region

    Carlos Carballo

    Renaldo Soto

    Walter Iglesias

17. Comision CentroAmericano Ambiente y Desarrollo (CCAD), San Salvador

    Raphael Guillen, Sectoral Specialist

Thursday, November 3

18. Ministerio de Agricultura y Ganaderia (MAG)

    Julio Alberto Olano, Director, Dirección General de Ordenamiento Forestal, Cuencas y Reigo

19. Unión de Cooperativas de la Reforma Agraria Productoras Beneficiadoras y Exportadoras de Café (UCAPROBEX), San Salvador

    Néstor Ulices Palma, Director General

20. Ministerio de Medio Ambiente y Recursos Naturales (MARN), San Salvador

    Carolina Canales

    Wilfredo Fuentes

21. Banco Multisectoral de Inversion (BMI), San Salvador

    Samuel Salazar

22. Consejo Salvadoreño del Café (CSC)

Tomás Ovidio Bonilla, Chief of Export Department

Friday November 4

23. US Agency for International Development, San Salvador

Brad Carl, Natural Resources Officer

Rafael Eduardo Cuellar, Manager of Agricultural Projects

24. Neumann Kaffee Gruppe, San Salvador

Carlos Eduardo Lainez, Director General, Tropical Farm Management El Salvador

APPENDIX 2. ARCGIS TRAVEL TIME MODEL

Impedance-weighted distances were calculated in ArcGIs by the following method. First, impedances were assigned to each plot to account for slope and whether or not a road was present. More specifically, we used the following formulas: for plots on paved roads, impedance is equal to one plus the square root of slope (in degrees); for plots on secondary roads, impedance is equal to three plus the square root of slope; and for all other plots impedance is equal to 10 plus three times the square root of slope. Calculated in this manner, impedance in our study area ranges from 1 to 190, and can be interpreted as the inverse ratio of the rate of travel in hundredths of a kilometer per hour. Thus, the rate of travel on a perfectly flat plot on a paved road is 100 kilometers per hour and the rate of travel on a steep plot with no road is 0.95 kilometers per hour. Having assigned impedances to each pixel, we used standard iterative techniques to find three minimum impedance routes: (i) from each plot to the nearest road; (ii) from the nearest road to the nearest *beneficio* and then on to each of two coffee market export centers—either Acahutla in coastal western El Salvador or to the Guatemalan border town of San Cristobal; and (iii) from the nearest road to the nearest city with a population greater than 19,000. The cities with population greater than 19,000 are: Acajutla, Aguilares, Ahuachapan Apopa, Chalchuapa, Cojutepeque, Ilopongo, Izalco, La Union, Los Planes, Nueva San Salvador, Puerto El Triumpho, Quezaltepeque, San Martin, San Miguel, San Rafael Oriente, San Salvador, San Vicente, Santa Ana, Sonsonate, Usulutan, Zacatolecoluca. We assume that primary rivers can only be crossed on an existing bridge and ignore other rivers and waterways. Finally, we convert these weighted distances into travel times in hours. Because our assumptions imply a linear relationship between impedance-weighted distance and the time needed to travel that distance, this conversion simply involves dividing by a constant. Thus, the variables TT_RD, and TT_MK, and TT_CY may be interpreted as total travel times in minutes.

As discussed, in the report, virtually all Salvadoran coffee is processed in a *beneficio* and then exported. Therefore, travel time from a plot to coffee markets is equal to the sum of: travel times from: (i) the plot to the nearest road; (ii) the nearest road to the nearest *beneficio*; (iii) the nearest *beneficio* to an export center. Virtually all exports are shipped from one of two export centers: Acahutla in coastal western El Salvador or Guatemala ports (La Hachadura, St. Tomas, and Puerto Barrios) reached via the Salvadoran border town of San Cristobal. According to PROCAFE, a *beneficio's* choice between these two export centers depends on market conditions, not on the proximity of the *beneficio* to the centers. Furthermore, between since 1990, the average annual percent of Salvadoran coffee shipped from Acahutla versus Guatemala has declined dramatically due to disruptions caused by the civil war and significant improvements in Guatemalan ports infrastructure. In the early 1990s, 70% of Salvadoran coffee exports were shipped from Acahutla and were 30% were shipped from Guatemala. Today, however, 25% of Salvadoran exports are shipped from Acahutla and 75% are shipped from Guatemala. We assume that TT_MK is a weighted average of travel times from the nearest road to Acahutla (25%) and San Cristobal (75%). We ignore travel times inside Guatemala since they are invariant to location of plots within El Salvador and, therefore, would not help to explain variation in the probability of clearing across plots.

FIGURES

Figure 1. Major coffee-growing areas in El Salvador in 1993 (West, Center, East)

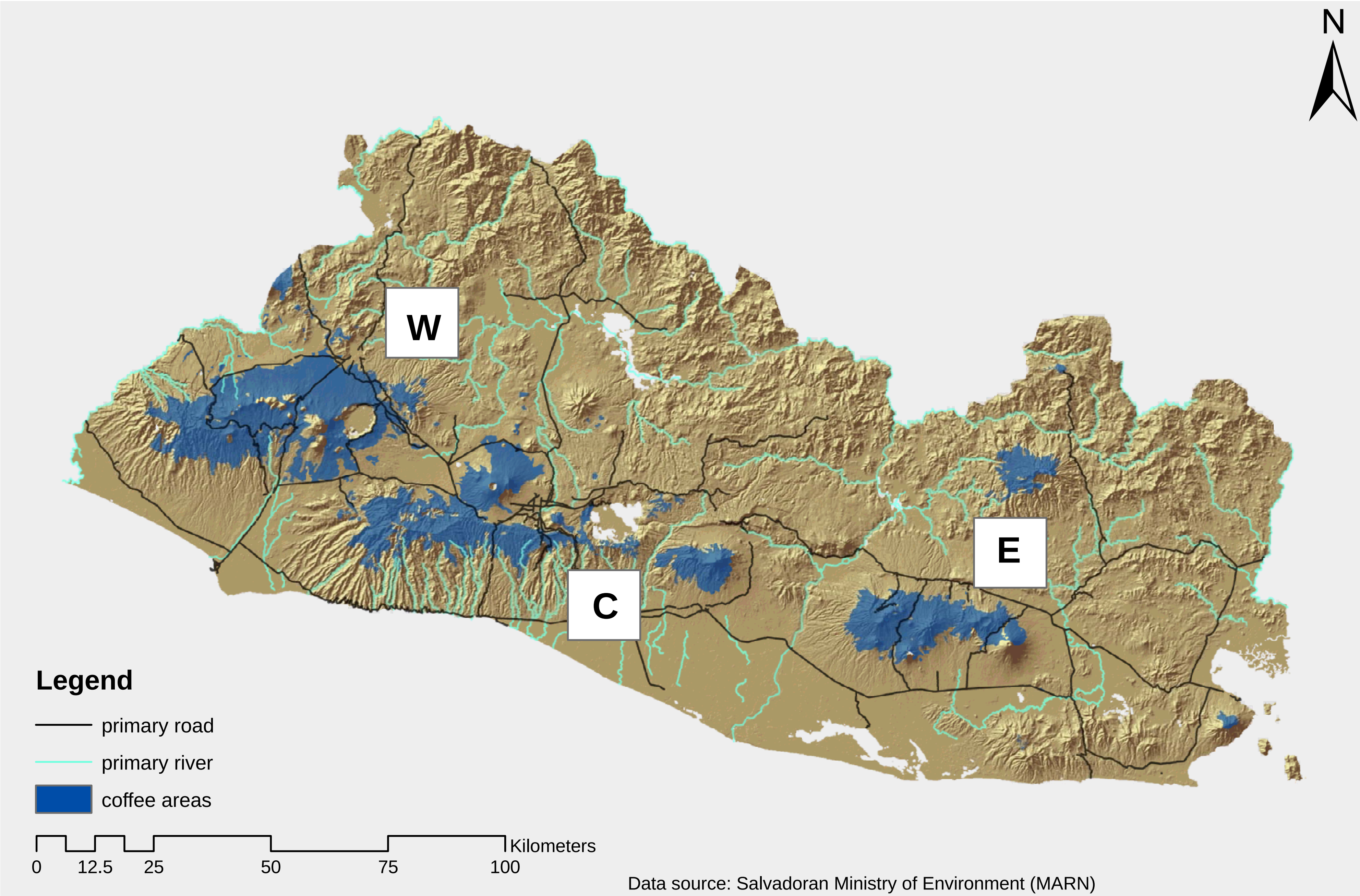


Figure 2. Land cover in 1990 in major coffee growing areas (West, Center, East)

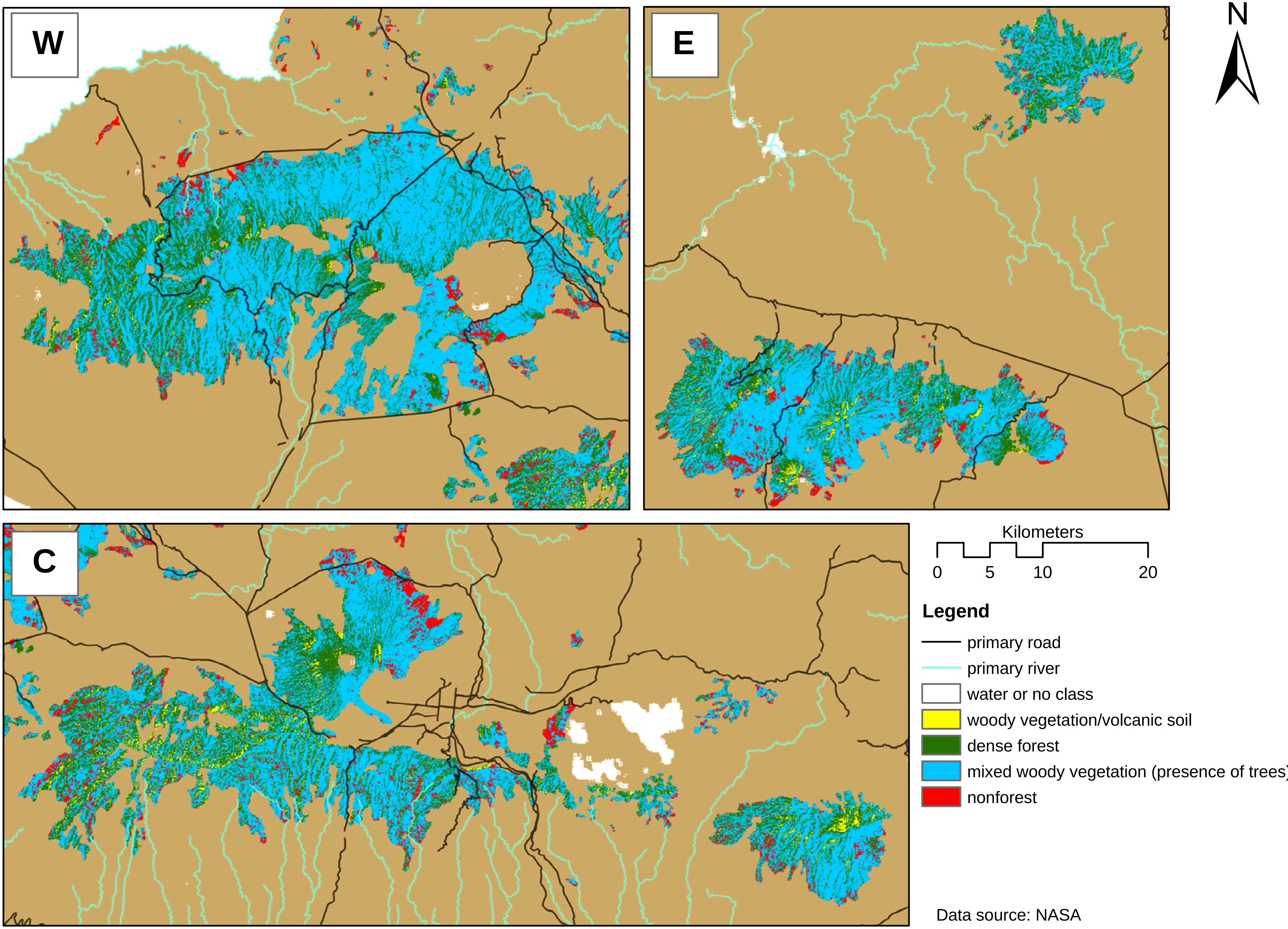


Figure 3. Land cover in 2000 in major coffee growing areas (West, Center, East)

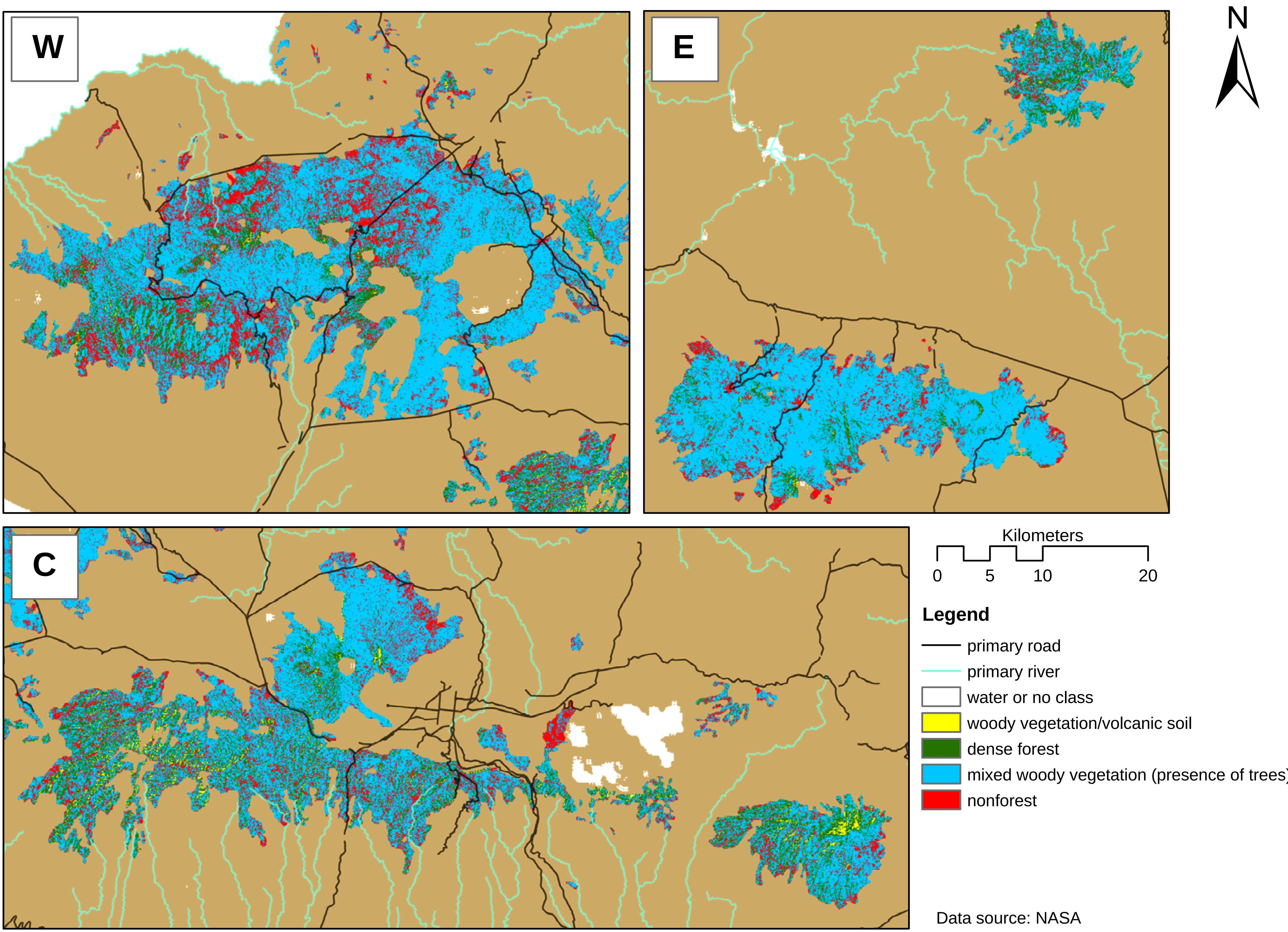
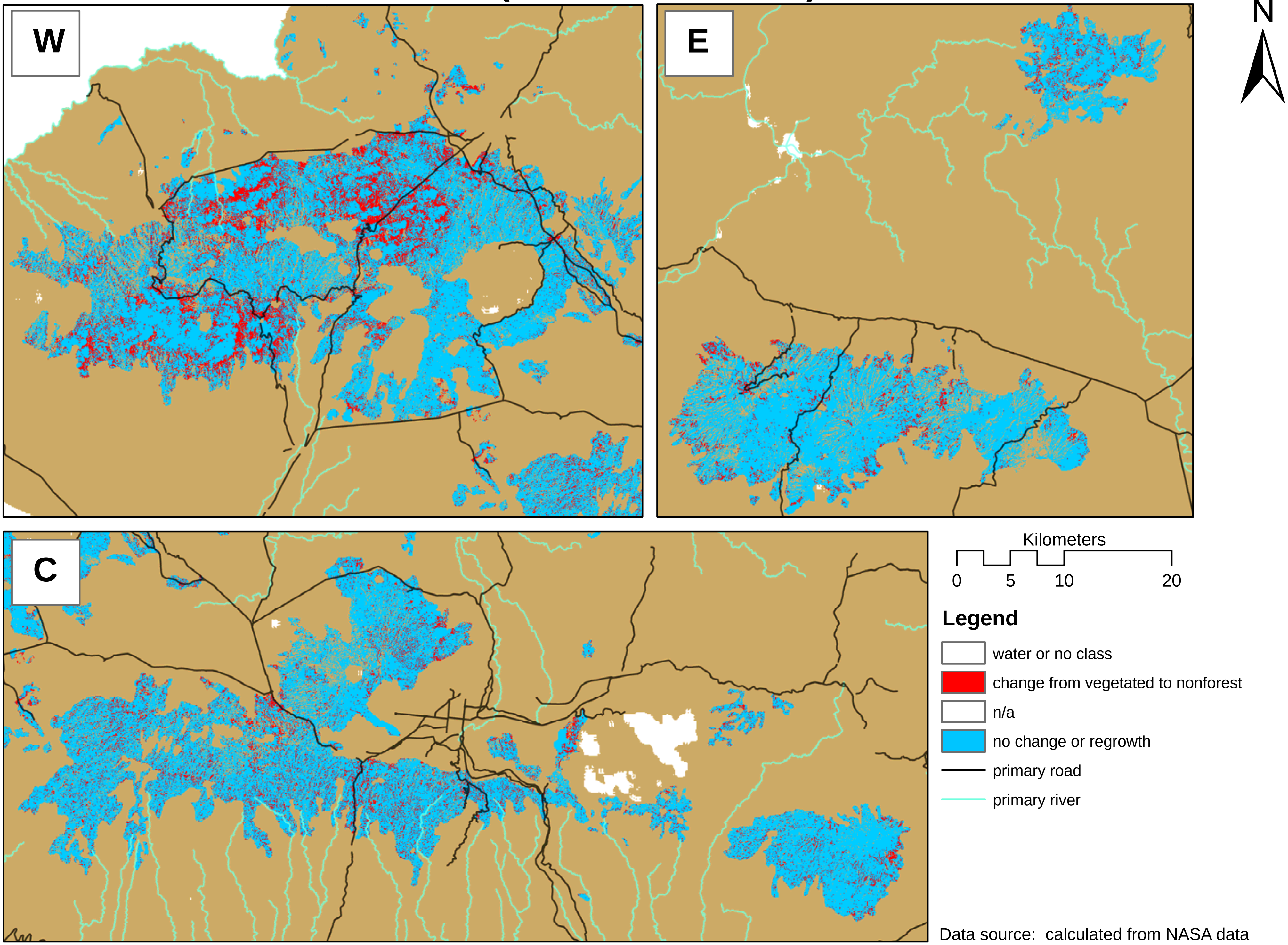
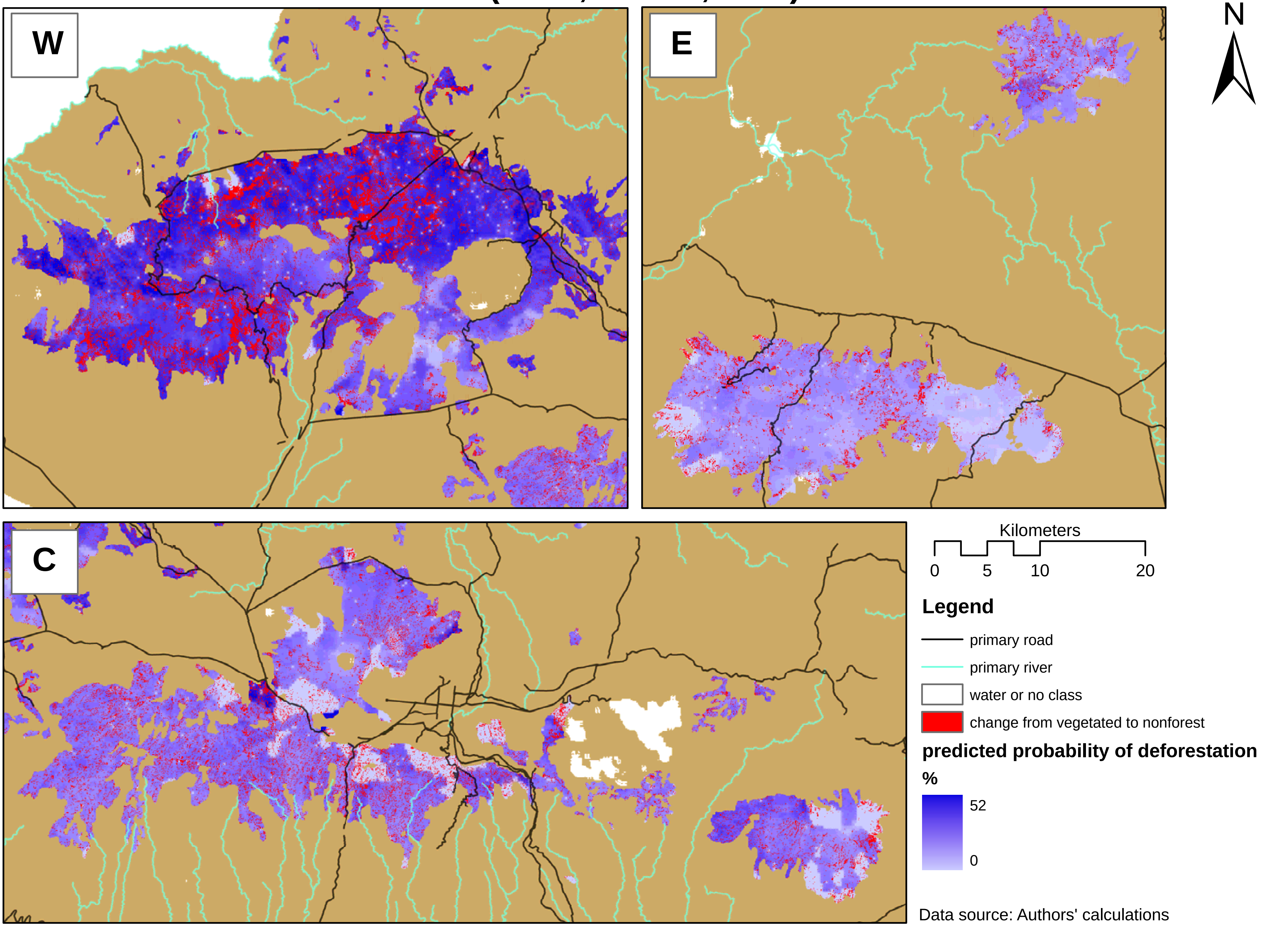


Figure 4. Clearing between 1990 and 2000 in major coffee growing areas (West, Center, East)



Data source: calculated from NASA data

Figure 5. Predicted probability of deforestation in major coffee growing areas (West, Center, East)



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