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Tree Cover Loss in El Salvador's Shade Coffee Areas

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Abstract

Shade coffee farms in Central America provide important ecological services. But because international coffee prices have fallen since 1990, many have been cleared to make way for more remunerative land uses. This problem is of particular concern in heavily deforested El Salvador, where a large share of the remaining tree cover is associated with shade coffee. We use satellite images, stakeholder interviews, and secondary data to analyze the magnitude, characteristics, and drivers of clearing in El Salvador's shade coffee areas during the 1990s. We find that 13 percent of these areas was cleared, mostly in middle- and high-altitude regions. Falling coffee prices were not the only drivers of this phenomenon, however: a downward spiral of on-farm investment and yields, debt, poverty, urbanization, migration, and weak land use regulation also contributed. Our findings suggest that stricter enforcement of land use and land cover regulations is urgently needed to prevent further clearing.

Key Words: shade coffee, land use, land cover, deforestation, El Salvador

JEL Classification Numbers: Q15, Q17, Q18, Q23

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1. Introduction

In 2001, after a decade of decline interrupted by short-term spikes, inflation-adjusted world coffee prices dropped to their lowest levels in a half-century. The causes of this phenomenon, commonly referred to as the coffee crisis, included the collapse of the international coffee cartel in the late 1980s, 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 to pre-1990 levels, at least not in the near term (Varangis et al. 2003). The coffee crisis has caused economic dislocation in Central America, where coffee is a leading agricultural sector (World Bank 2005). Less well known is that the crisis has also had adverse environmental impacts (IADB et al. 2002). Most important, it has led to a significant loss of tree cover and related ecological services.

On most Central America coffee farms, tree cover is used to moderate temperature, humidity, and sunlight. Unlike most agricultural land uses, this mixed agroforestry system provides many of the same ecological services associated with natural forests—harboring biodiversity, preventing soil erosion, sequestering carbon, facilitating aquifer recharge—albeit at a lower level in most cases. Shade coffee's biodiversity benefits are particularly notable. The crop 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). As coffee prices have declined, however, tree cover in Central American shade coffee areas has been cleared to make way for more remunerative land uses, including urban development, conventional farming,

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ranching, and logging. As a result, critical ecological services have been lost. Some of the consequent damages—for example, species loss and soil erosion—may be irreversible or nearly so.

Although this problem is beginning to attract the attention of policymakers (see, e.g., IADB et al. 2002; Varangis et al. 2003; ICO 2004), it remains poorly understood. Little is known about its magnitude, characteristics, and drivers. As a first step toward filling this gap, this paper analyzes tree cover loss in El Salvador's shade coffee areas during the 1990s. We focus on El Salvador because its shade coffee provides particularly important ecological services. El Salvador is the most densely populated country in Latin America and also the most severely deforested. Less than 10 percent of its natural forests survive, and a significant share of remaining tree cover is associated with shade coffee (FAO 2002). We focus on the decade of the 1990s because, as discussed below, the digital land cover maps needed to analyze tree cover loss are available for this decade.¹ In addition to land cover maps derived from satellite images, our analysis relies on primary and secondary documents and interviews with representatives of coffee cooperatives, government regulatory agencies, trade associations, coffee exporters, development banks, nongovernmental organizations, and research institutes.

The remainder of this paper is organized as follows. Section 2 provides background information on El Salvador's coffee sector. Section 3 presents the results of an analysis of satellite images. Section 4 discusses the factors that contributed to tree cover loss in shade coffee areas during the 1990s. Section 5 identifies the land uses that substituted for shade coffee. Finally, Section 6 offers a summary of our principal findings and a discussion of their policy implications.

¹ 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). 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.

2. El Salvador's Coffee Sector

Coffee in El Salvador grows in three main areas: the western region, located in the Apaneca-Ilamatapac mountain range; the central region, located in the El Balsamo and Chichontepc volcano mountain ranges; and the eastern region, located in the Tecapa Chinameca and Cachuatique mountain ranges (Figure 1). In the 2003–2004 harvest season, coffee was planted on a total of 161,000 hectares. Fifty-two percent of this acreage was in the west, 29 percent in the center, and 19 percent in the east. More than 45 percent of El Salvador's coffee acreage lies above 800 meters above sea level (m.s.l.) (PROCAFE 2004).

Ninety-five percent of El Salvador's coffee is shade grown (GEF 1998). The type and density of shade cover that farmers use depend partly on the altitude and local microclimate. Coffee farms in lowland areas typically have 40 percent shade cover, while those in highland areas typically have 20 percent shade cover (Gomez 2005).

In the 2003–2004 harvest season, El Salvador produced almost 2 million quintals (46-kg. sacks) of green coffee (PROCAFE 2004). This production represented about 1 percent of the world's total that season and 11 percent of Central America's total (ICO 2006). Ninety percent of the crop was exported, generating over \$120 million in revenue. In the 2003–2004 season, the coffee sector employed more than 57,000 people permanently and paid some \$14 million in wages (PROCAFE 2004).

Most Salvadoran coffee is relatively high in quality. The Salvadoran Coffee Council assigns coffee one of three quality standards depending on the altitude at which it is grown: "central standard" for coffee grown at 600–800 m.s.l.; "high grown" for coffee grown at 800–1,200 m.s.l.; and "strictly high grown" for coffee grown above 1,200 m.s.l. Almost three quarters of Salvadoran coffee exports are either high grown or strictly high grown, and another 5 percent is "gourmet." Although other types of specialty coffees, including "organic," "Rainforest Alliance certified," and "fair trade," have appeared in the past several years, they still make up less than 1 percent of overall exports (PROCAFE 2004).

The Salvadoran coffee sector suffered from a series of 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 (1994–1995 through 1997–1998) in part because of a severe freeze in Brazil that reduced world supply, but then continued an overall downward slide in 1998–1999 (PROCAFE 2004). Several climatic 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 percent between 1991–1992 and 2000–2001, while exports and export revenue fell by approximately 20 percent. The impact of lower prices between 1991–1992 and 2003–2004 was even more dramatic. Production fell by 38 percent and yields by 36 percent. Wages and permanent employment fell by 64 percent, and exports and export revenue fell by 37 percent.

3. Data from Satellite Images

To analyze tree cover loss in El Salvador's shade coffee areas, we rely on digital land cover maps for 1990 and 2000. Both maps were created by the NASA Jet Propulsion Laboratory by using a single land cover methodology to classify 30-meter resolution LANDSAT satellite images.² The maps do not distinguish between shade coffee and other types of tree cover. Therefore, to identify areas where coffee was growing, we used a Salvadoran Ministry of Agriculture (MAG) land use map for 1992–1994. The MAG map identifies only the perimeters of the three main coffee-growing areas, which collectively encompass 197,000 hectares. In 1993–94, 164,000 hectares, representing 83 percent of the MAG-defined coffee area, were planted in coffee (PROCAFE 2004).

To create the 1990 and 2000 land cover maps, NASA's Jet Propulsion Laboratory assigned each 30-meter pixel in the underlying satellite image to one of five categories, three of which—"dense forest," "woody vegetation," and "mixed woody vegetation"—entail tree cover, and two of which—"water or no class" and "nonforest"—do not. Table 1 presents data on tree cover in the three coffee areas. A comparison of 1990 tree cover inside the coffee regions (third column from the left) and outside the coffee regions (last column on the right) suggests that until 1990, shade coffee provided a bulwark against tree cover loss. Although 51 percent of the noncoffee area had no tree cover, only 7 percent of the coffee regions had none. The data clearly show that considerable tree cover in the coffee regions was lost between 1990 and 2000. For all three coffee regions, land without tree cover increased from 7 percent to 17 percent during this time.

² Dr. Sassan Saatchi, a Senior Researcher at NASA's Jet Propulsion Laboratory, supervised the creation of the maps and generously agreed to let us use them for this project.

Table 1. Tree Cover 1990 and 2000, by Region

<i>Land cover</i>	<i>All coffee regions</i>		<i>West</i>		<i>Center</i>		<i>East</i>		<i>Noncoffee regions</i>	
	<i>ha.</i>	<i>% regions</i>	<i>ha.</i>	<i>% region</i>	<i>ha.</i>	<i>% region</i>	<i>ha.</i>	<i>% region</i>	<i>ha.</i>	<i>% country</i>
1990										
Tree cover	181,410	92	78,970	94	61,970	91	40,470	92	888,350	49
No tree cover	14,590	7	4,870	6	6,410	9	3,320	8	927,480	51
Water/no class	710	0	330	0	20	0	360	1	NA	NA
<i>Total</i>	196,710	100	84,170	100	68,400	100	44,150	100	1,815,120	100
2000										
Tree cover	161,680	82	66,830	79	56,240	82	38,610	87	999,210	55
No tree cover	34,320	17	17,010	20	12,130	18	5,180	12	816,610	45
Water/no class	710	0	330	0	20	0	360	1	NA	NA
<i>Total</i>	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.

We define a pixel as having been “cleared” if it had tree cover in 1990 but not in 2000.³ Table 2 presents data on clearing, and Figure 2 represents it graphically. Fully 13 percent of land area in the three coffee regions was cleared during the 1990s. The percentage of land cleared differed dramatically across the three coffee regions. It was highest in the western region (17 percent) and lowest in the eastern region (7 percent). The percentage of land cleared inside the coffee area (13 percent) was slightly higher than that outside the coffee area (12 percent).

Table 2. Clearing 1990–2000, by Region

<i>Land cover</i>	<i>All coffee regions</i>		<i>West</i>		<i>Center</i>		<i>East</i>		<i>Noncoffee regions</i>	
	<i>ha.</i>	<i>% regions</i>	<i>ha.</i>	<i>% region</i>	<i>ha.</i>	<i>% region</i>	<i>ha.</i>	<i>% region</i>	<i>ha.</i>	<i>% country</i>
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
<i>Total</i>	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.

Table 3 presents data on clearing by altitude range. Most of the stakeholders we interviewed 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,

³ 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.

were relatively low. Table 3 demonstrates that this conventional wisdom is incorrect. For all three coffee regions, 46 percent of clearing occurred between 800 and 1,200 m.s.l., where coffee is classified as high grown, and another 15 percent occurred above 1,200 meters, where coffee is classified as strictly high grown.

Table 3. Clearing 1990–2000 in All Three Coffee Regions, by Altitude Range

<i>Range</i>	<i>Area in range</i>		<i>Cleared in 1990</i>		<i>Cleared in 2000</i>		<i>Cleared 1990–2000</i>		<i>% all clearing</i>	
	<i>m.s.l.</i>	<i>ha.</i>	<i>% region</i>	<i>ha.</i>	<i>% range</i>	<i>ha.</i>	<i>% range</i>	<i>ha.</i>		<i>% range</i>
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 also shows that the conventional wisdom reflected the situation prior to 1990, when 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. But since most clearing during the 1990s occurred above 800 m.s.l., by 2000, these percentages were more or less equal in each of the three altitude ranges.

4. Factors Driving Tree Cover Loss in the 1990s

As discussed in the introduction, low international coffee prices were an important driver of tree clearing in El Salvador's coffee regions during the 1990s. However, interviews with coffee sector stakeholders as well as primary and secondary documents suggest that six complementary factors contributed to or influenced tree cover loss in El Salvador's shade coffee areas during this period.

4.1. Downward Spiral of On-Farm Investment and Yields

The coffee crisis led to a downward spiral of on-farm investment and yields in the coffee sector. The spiral began when growers reacted to low prices by cutting back or completely eliminating farm management activities, such as pruning and the application of fertilizers and pesticides, which together account for approximately half of per hectare coffee production costs (World Bank 2001). Although such cost-cutting measures helped balance cash accounts in the short term, they also had short- and long-term negative impacts on yields. Reduced yields led to even lower profits, and lower profits led to further cutbacks in farm maintenance (Batz et al.

2005). On average, yields fell by more than 20 percent, from 19-plus quintals per hectare in the 1991–1992 growing season to about 15 quintals per hectare in the 2000–2001 season (PROCAFE 2004).

4.2. Debt

Coffee growers in El Salvador depend on annual infusions of working capital from large private banks, mainly channeled through cooperatives and coffee mills. On average, growers require approximately \$40–\$45 of credit per quintal of coffee produced to hire farm labor (World Bank 2001). During the 1990s, the coffee growers borrowed an average of over \$200 million per year, far more than any other agricultural sector (PROCAFE 2004). After the onset of the coffee crisis, growers' profits were so low that they were unable to repay their loans. Nevertheless, for several years banks continued to extend credit, knowing that farmers needed to produce enough coffee to repay their debts. As a result, debts mounted. Today, the total outstanding debt in the coffee sector is estimated at \$200 million to \$400 million, an average of \$100–\$210 per quintal or \$1,200–\$2,500 per hectare.

Debt contributed to tree cover loss during the 1990s in a number of ways. Indebted growers sometimes sold their land, in part or whole, to developers, conventional farmers, or ranchers in order to liquidate debt. In some cases, banks foreclosed on farms that had been used as collateral and did the same thing. In addition, as discussed below, indebted growers sometimes sold trees on their land for cash.⁴

4.3. Poverty

During the 1990s, poverty was pervasive in rural areas of El Salvador, including coffee-growing areas. At the beginning of the 1990s, 66 percent of all rural households in El Salvador were classified as poor, and 34 percent were classified as extremely poor. Although national poverty rates fell during the 1990s, most of the reductions were in urban not rural areas (Cuéllar et al. 2002).

⁴ Three of the five cooperatives interviewed reported that they were heavily in debt and that all of their profits are allocated to servicing their loans, leaving no funds for investment. 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. Similarly, a large (945 hectare) reform cooperative in the west region reported that they owe \$1.8 million and pay \$225,000 each year to service the debt.

Rural poverty contributed to tree cover loss in coffee-growing areas in several ways. First, after the onset of the coffee crisis, poor, small-scale growers unable to meet their basic subsistence needs from coffee alone cleared portions of their farms to grow maize, beans, and other basic food crops. This phenomenon has been a common response to poverty and income variability among all types of rural households in El Salvador, and it is a leading cause of tree cover loss in other Mesoamerican shade coffee-growing regions (Rodríguez-Meza et al. 2004; Blackman et al. 2007). In addition, poor rural households sold trees for lumber and firewood, both of which command a significant per unit price in El Salvador. Finally, in some cases, rural entrepreneurs harvested trees on abandoned or poorly supervised farms without obtaining permission.

4.4. Urbanization

With a 2000 population of 6.3 million inhabiting an area of just 21,000 square kilometers, El Salvador has more than 315 persons per square kilometer, making it the most densely populated country on the American continent. By comparison, Guatemala and Honduras have 104 and 58 persons per square kilometer (Cerrutti and Bertonecello 2003). Not surprisingly, given this density, El Salvador is an increasingly urban country. In 2000, 55 percent of El Salvador's population lived in urban areas, up from 39 percent in 1970 (Cerrutti and Bertonecello 2003). Land under urban uses grew from 0.8 percent of the national territory in 1965 to 5 percent in 1995 (World Bank 1997).

Demand for land for housing 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 farms, have been divided into small lots and sold to construction companies or directly to homesteaders, a process known as "lotification." Lotification does not cater just to the middle or upper class. Rather, small lots averaging 250 square meters, with no preexisting buildings, infrastructure, or services, are sold at modest prices to low-income households (World Bank 1997).

Strong 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 use unprofitable and creating powerful incentives for coffee growers to sell their farms (World Bank 1997).

4.5. Migration and Remittances

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. This phenomenon, along with population growth, has caused 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 percent to 67 percent. By comparison, the share of the country's population living in the southeast fell from 28 percent to 20 percent, and the share of the population living in the north fell from 19 percent to 13 percent (Cuéllar et al. 2002). To the extent internal migration has exacerbated population pressures in the southwest, it has contributed to clearing of coffee farms in this area, for both urban and agricultural uses.

Although internal migration during the 1990s was significant, it paled in comparison with external migration. In 2000, for example, three-quarters of rural migration was external, and virtually all of it was to North America (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 percent of these migrants live in the United States (Cuéllar et al. 2002).

Given this massive external migration, remittances have become a critical feature of El Salvador's economy. In 1999, Salvadoran migrants sent home more than \$1.5 billion, an amount that represented 13 percent of El Salvador's GDP, 64 percent of its export earnings, and almost 700 percent of its foreign investment (Andrade-Edkhoff 2001). Nationally, between 1992–93 and 2000, the percentage of households receiving remittances rose six percentage points, from 14 to 20 percent. The increase was larger in rural areas (from 13 to 20 percent) than in urban areas (16 to 19 percent). The average amount of remittances per household also increased, from \$76 to \$121, the equivalent of the monthly minimum wage (Cuéllar et al. 2002).

External migration and associated remittances are likely to have had both beneficial and detrimental effects on tree cover in shade coffee regions during the 1990s. On the one hand, external migration may have dampened urbanization. Also, remittances may have enabled coffee-growing households to continue producing despite low prices and scarce credit and to avoid clearing trees to harvest the lumber or grow subsistence crops. On the other hand, however, according to stakeholders interviewed for this report, remittances have fueled the demand for urban land uses and have financed the 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, making coffee production less profitable.

4.6. 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*, or 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.⁵ In practice, these requirements were frequently ignored. Even when they were heeded, the criteria for obtaining permits were rarely enforced and environmental impact assessments were not required. Prior to the passage of a new forestry law in 2002, MAG almost never rejected a request for a permit to clear forest (Celis, October 28, 2005; Gómez, October 24, 2005; Olano, November 3, 2005).

Environmental management in El Salvador took a major step forward in 1998 with the passage of the Environmental Law and the creation of the Ministry of the Environment and Natural Resources (*Ministerio de Medio Ambiente y Recursos Naturales*, or MARN). By law, MARN is required to issue permits for any changes in land use. According to government interviewees, however, MARN does not have the resources to conduct a detailed review of permit applications and approves the vast majority submitted (Celis, October 28, 2005; Olano, November 3, 2005).

5. Land Uses Replacing Shade Coffee

To our knowledge, no hard data are available on the specific land uses that replaced shade coffee between 1990 and 2000. Our land cover maps are of little use in this regard because they lump all land uses that entail clearing into a single “nonforest” class. As a first step toward filling this gap, we administered a questionnaire to the three regional managers of the Salvadoran

⁵ 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).

Coffee Research Institute (*Fundación Salvadoreña para Investigaciones del Café*, or PROCAFE), El Salvador's parastatal research and technical extension organization.

The PROCAFE managers' answers suggest that the majority of clearing between 1990 and 2000 in each of the three coffee regions was due to urbanization (Table 4). Urbanization played the largest role in the western region, where it accounted for fully 90 percent of clearing, and in the central region, where it accounted for 68 percent of clearing (Table 5). Felling trees to harvest lumber or firewood played a significant role in the eastern region, where it accounted for 20 percent of clearing. Finally, row crops played a significant, albeit minor, role in each region.

Table 4. Activities Responsible for Clearing 1990–2000, by Region

Activity	Percentage		
	West	Center	East
Urban land uses	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

^aNo land use substituted for coffee.

Source: survey of PROCAFE regional managers.

6. Conclusion

To summarize briefly, using data from satellite images, we found that tree cover loss in El Salvador's coffee areas during the 1990s was extensive: fully 13 percent of the land inside the three main coffee-growing areas was cleared. Contrary to conventional wisdom, most of this clearing occurred in middle- and high-altitude areas, not in lowland areas. Interviews with stakeholders and a review of secondary evidence suggest that falling coffee prices were not the only driver of tree cover loss during the 1990s. Rather, a complex web of interrelated factors contributed, including a downward spiral of on-farm investment and yields, debt, poverty, urbanization, migration, and weak land use and land cover regulation. Finally, data from interviews with coffee researchers suggest that urbanization was responsible for the majority of clearing in the coffee regions during the 1990s, particularly in the west and center.

These results have several policy implications. First, 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 pre-1990 levels since then. In heavily deforested El Salvador, shade coffee provides important ecological services. To prevent soil erosion, flooding, biodiversity loss, and other types of environmental degradation that would result from further tree cover loss, action must be taken quickly.

Second, command-and-control land cover and land use restrictions are needed to stem tree cover loss. In the central and western regions, where more than three-quarters of El Salvador's coffee is grown, urbanization and an inflow of financial capital from remittances have pushed land prices well above the net present value of future returns to coffee, thereby creating strong incentives for growers to sell their land to developers. In these areas, market-based conservation approaches, such as payments for environmental services and coffee certification, are not likely to be effective because the financial incentives they provide for continuing to grow coffee are significantly smaller than those offered by the land market. Unfortunately, however, command-and-control regulation is not likely to be effective in the near term. To date, by all accounts, land use and land cover regulation in El Salvador has proven toothless. It will undoubtedly take some time to build the political will and institutional capacity to enforce these policies. An interim solution may be 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.

Finally, our results suggest that efforts to improve coffee quality and marketing can help stem further tree cover loss. Because they have a comparative advantage in producing high-quality coffee, many highland growers in El Salvador have responded to the coffee crisis by boosting quality and marketing to obtain higher farm-gate prices. Our analysis shows that these efforts to improve coffee quality and marketing are targeting areas where most deforestation is occurring.

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

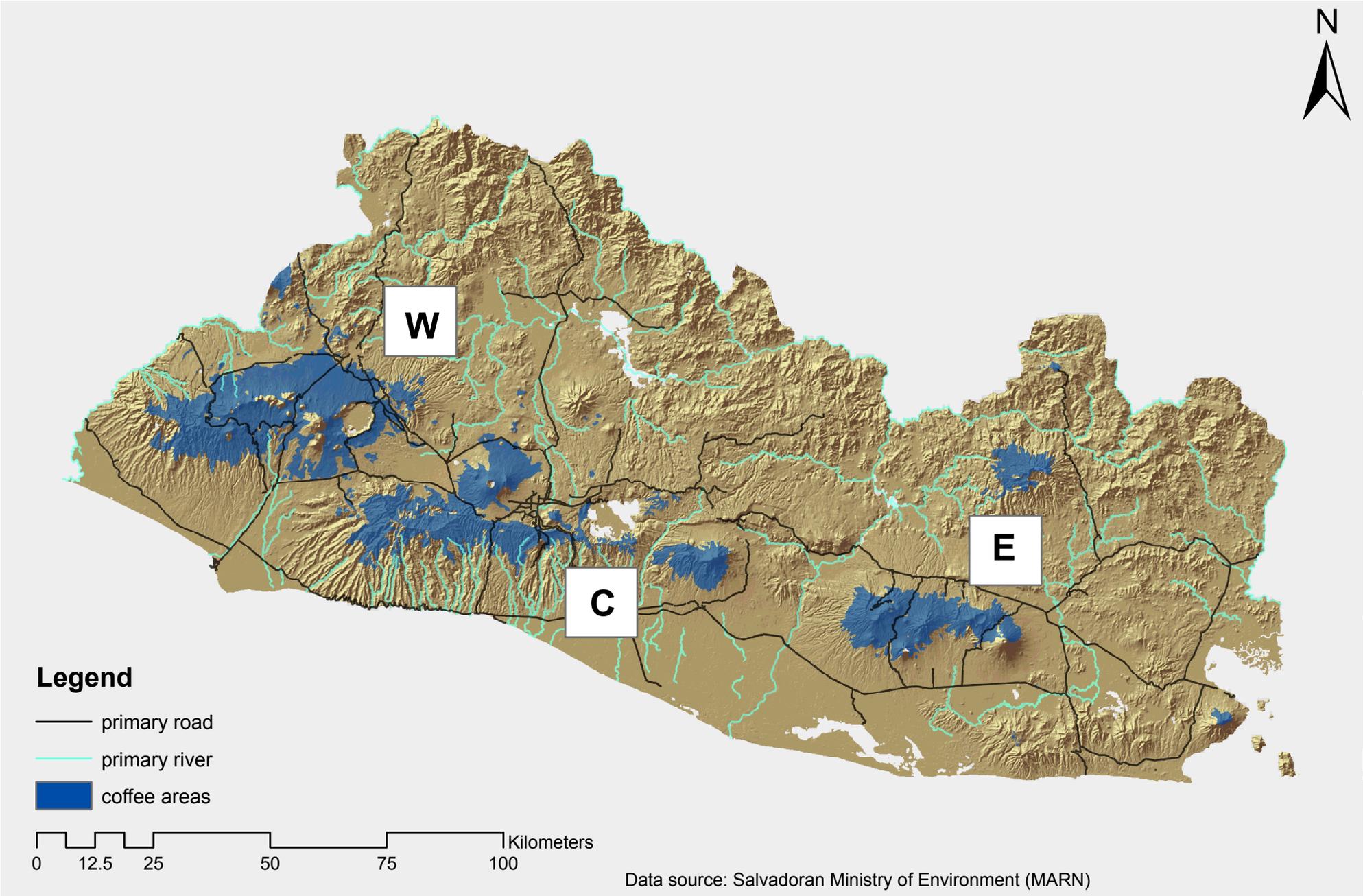


Figure 2. Clearing between 1990 and 2000 in major coffee growing areas (West, Center, East)

