

Historical drivers of landscape and dietary change in an agricultural frontier

Bosawas Biosphere Reserve, Siuna, Nicaragua

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Summary

Deforestation in Central America's rain forests is a growing problem that is typically attributed to the expansion of the agricultural frontier, yet little is known about the historical drivers of migration, settlement and forest loss. This chapter presents the results from a scoping study conducted in northeastern Nicaragua in the municipality of Siuna. Siuna has a rich history of colonization and nearly the entire municipality shares jurisdiction with the Bosawas Biosphere Reserve. The study landscape is also part of the Nicaragua-Honduras Sentinel Landscape, a multi-year collaborative research program site of the CGIAR Consortium. This chapter highlights the importance of resource extraction, natural disasters, policies and politics, economics, and the role of local and global conflicts and their aftermaths in influencing human migration and settlement patterns. We also discuss important conservation management and human rights issues related to the history of settlement within Siuna and the Reserve.

5.1 Introduction

Deforestation is a growing problem worldwide, particularly in regions where population growth, human settlement and migration are increasing within protected area boundaries, and associated land uses, livelihood and food security needs result in the

conversion of forest to farms. The conversion of forest to farming systems is regarded as the most common and widespread land-cover or land-use change and as such, agriculture is viewed as the greatest threat to forest conservation (Rudel et al. 2009; Gibbs et al. 2010; Lambin and Meyfroid 2011). Settlement of forestland, commonly termed colonization, accounts for the majority of tropical deforestation in Latin America (Geist and Lambin 2002). However, despite an agreement that colonization is the problem, there is a lack of understanding in many frontier forests about what has historically driven settlement and migration into a region over time.

Recent research on deforestation trends in Central America has revealed that Nicaragua has one of the highest deforestation rates in the region. Hansen et al. (2013) report a net forest loss of 7563 km² in Nicaragua between 2000 and 2012, accounting for 34% of the net forest loss in Central America as a whole. Aide et al. (2013) reported a similar net forest loss of 7961 km² in Nicaragua between 2001 and 2010, the highest calculated deforestation rate in the region. Redo et al. (2012) reported Nicaragua to have the highest net deforestation rate (8574 km²) in Central America's moist broadleaf forest in 2000–2010 and the second lowest overall percentage of forest cover (29%). Redo et al. (2012) further reported that northeastern Nicaraguan municipalities of Waspam, Rosita, Bonanza and Siuna were “hot spots” of deforestation; each of these municipalities share jurisdiction with the Bosawas Biosphere Reserve.

This chapter examines and contributes to the theory that many ongoing processes and events act in concert and combine to drive temporal variation in the annual rates of deforestation. It is also reflective of the role of migration and subsequent forest clearing that occurs in agricultural frontiers and recognizes that there are push and pull factors that drive the migration (Geist and Lambin 2002; Carr 2009). A qualitative and narrative approach was used to provide a list of interrelated processes and events that have been responsible for the advance of Nicaragua's agricultural frontier into the municipality of Siuna and the Bosawas Biosphere Reserve. Specifically, this work seeks to address the following questions: What are the community perspectives of historical and present day drivers of land-use change? How does this vary between communities? What are the historical and present day drivers of migration and settlement in Siuna? How does settlement and migration history vary by community? What impact do local people perceive the historical changes in forest cover and land-use practices to have had on their food security and nutrition? What are the problems with food security and nutrition as perceived by local people?

5.2 Background

5.2.1 Bosawas Biosphere Reserve

North central Nicaragua is home to one of the largest terrestrial protected areas in Central America. The Bosawas Biosphere Reserve, known as Bosawas, is a UNESCO designated Man and Biosphere Reserve, the boundaries of which cover 15% of the country's land area, or approximately 20,000 km² (Figure 5.1). Bosawas is reportedly home to an estimated 3.5% of global biodiversity of flora and fauna including 500 species of butterflies, 200 species of

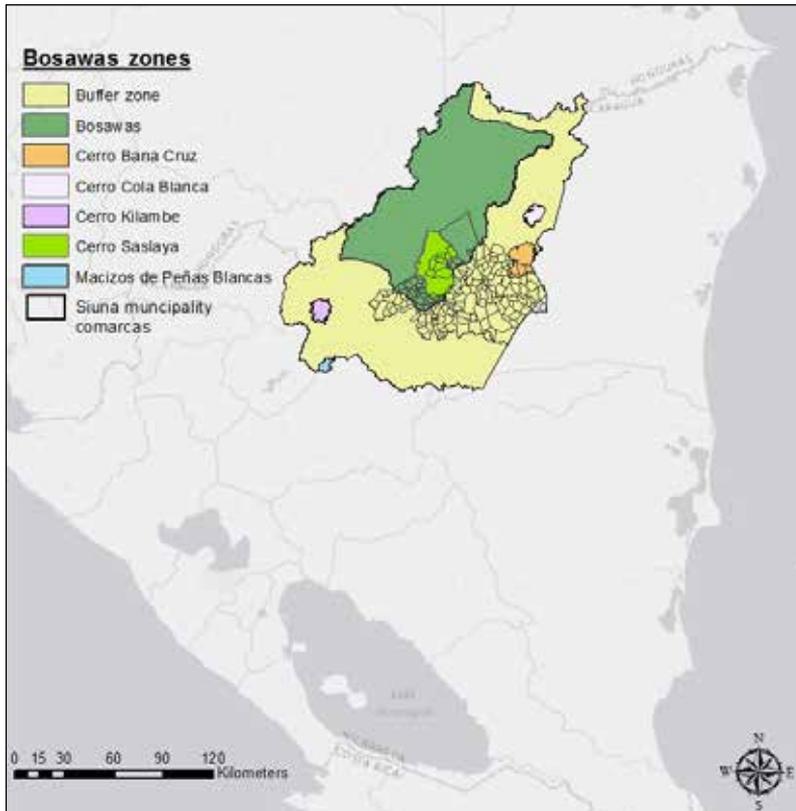


Figure 5.1 Bosawas Biosphere Reserve and Siuna Municipality with comarcas, Nicaragua.

dragonflies, 50 species of bats, 400 residential and 756 migratory birds, 120 species of mammals, 120 species of amphibians and reptiles, and 180 families of flora, including 400 species of orchids (Comisión Nicaragüense de Cooperación con la UNESCO 2011). Several of these species are rare in other parts of Central America, particularly the giant anteater, jaguar, harpy eagle and American crocodile, and a few are some of the world's last populations, for example Baird's tapir and the Central American spider monkey (SETAB 2012). These are but broad estimates as adequate data on the population status of wildlife, especially threatened species, is wanting due to a dearth of monitoring and assessment.

Bosawas together with three neighboring protected areas in Honduras (Rio Patuca National Park, Tawhaka Anthropological Reserve and Rio Plantation Biosphere Reserve) is the largest protected area complex of moist tropical forest north of the Amazon Basin. The Governments of Nicaragua and Honduras hope to have these four protected areas collectively designated as a UNESCO transboundary reserve known as Corazon del Corredor Biologico Mesoamericano (IEG 2011). The region has been coined the "Heart of Mesoamerica," known more formally as the Mesoamerican Biological Corridor. International efforts to create a connected system of protected areas in the region were initiated with a Joint Declaration signed in 1997 at the 19th Summit of

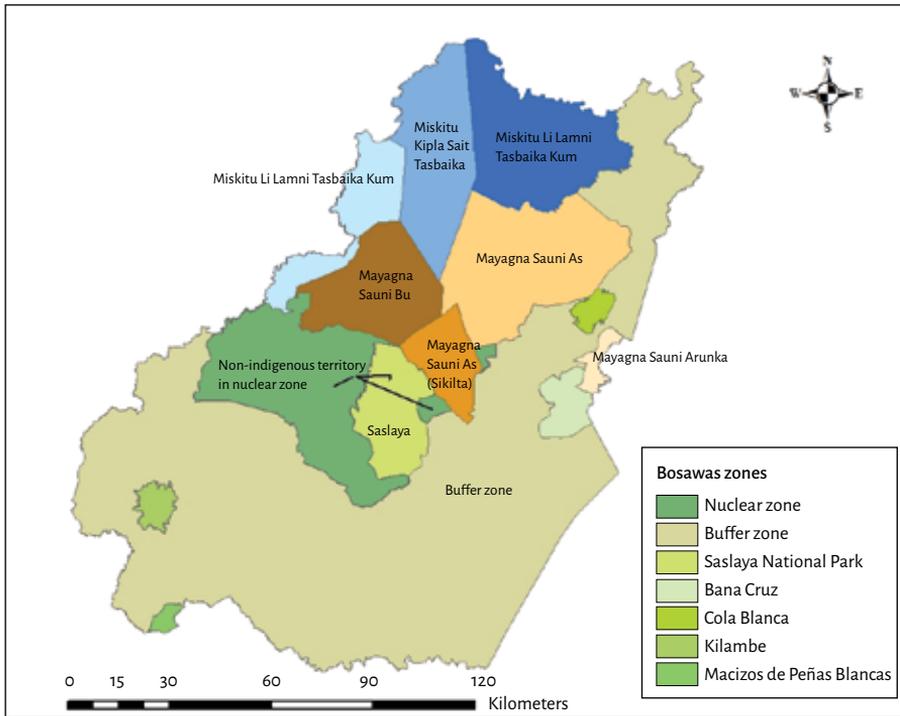


Figure 5.3 Bosawas with indigenous territories and zones.

Within the nuclear zone, approximately 80% of the land has been granted as common property indigenous land titles to Miskitu and Mayagna tribes (Figure 5.3) following their fight to win their traditional land titles (see Kaimowitz et al. 2003; Hayes 2007; Stocks et al. 2007; Hayes and Murtinho 2008; Larson 2010). The remaining 20% of the nuclear zone was not granted as indigenous territory and falls under jurisdiction of the municipalities of Siuna, San Jose de Bocay and Wiwili de Jinotega, affording them responsibilities for the land and resource management on behalf of the State. Mestizo peasants with origins throughout Nicaragua make up the majority of the population in this 20% of the nuclear zone. Few Miskitu or Mayagna live in the rural areas outside of their territorial boundaries but some have settled in urban areas.

5.2.2 Study landscape

This research focuses on Siuna municipality, which covers an area of 5039 km², divided into approximately 190 *comarcas* (political subunits of communities that are often divided further into *sectores*, or sectors). Nearly all of Siuna's *comarcas* are set within Bosawas (Figure 5.4). The majority of *comarcas* are located within the buffer zone, but a significant number are situated in Bosawas' nuclear zone mainly south of Saslaya National Park, known as Saslaya. Additionally, there are at least ten *comarcas* in Siuna found entirely or partially within the boundaries of Saslaya. In short, political boundaries of Siuna's *comarcas* overlap with different zones of Bosawas.

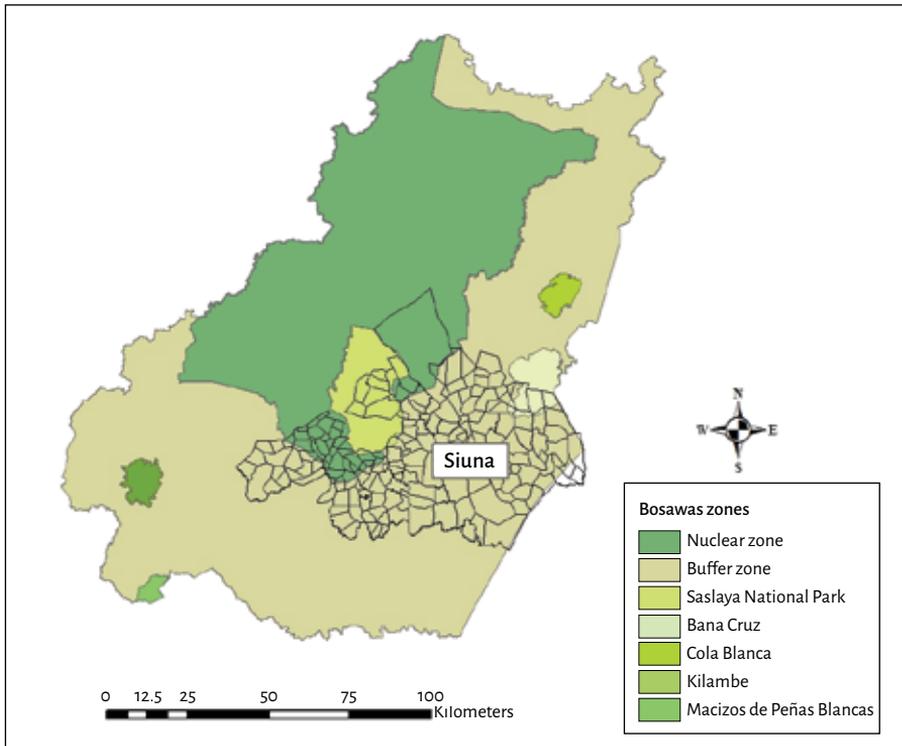


Figure 5.4 Siuna municipality in Bosawas with zones and *comarcas*.

In total, Saslaya's boundaries cover 633.8 km² (approximately 8% of Bosawas' nuclear zone). Saslaya contains the largest contiguous patch of old growth rainforest remaining outside of indigenous territory in southern Bosawas, which is partially attributed to the topographic conditions of the Saslaya mountain range. The highest peak (Cerro Saslaya) is 1371 masl. Deforestation has recently occurred both outside Saslaya's boundaries, as well as inside the park's boundaries in the northern region (through Siuna from the east and through San Jose de Bocay from the west).

Siuna is located halfway between both Managua (the capital) and the Atlantic coast town of Bilwi (Puerto Cabezas); the journey to both locations is approximately 8 hours. It is also connected to Matagalpa (an important agricultural hub) by highway (approximately 8 hours). The urban center (*cabecera*) of Siuna – Siuna town – is at the intersection of three highways connected to Managua, Puerto Cabezas and Matagalpa; the distance to each is 318 km, 210 km and 207 km respectively (Figure 5.5). Siuna was historically part of the Department of Zelaya but later become part of the Northern Atlantic Autonomous Region (the RAAN) – one of two autonomous regions in Nicaragua – in 1987. Siuna is also part of a region known as the mining triangle that includes the nearby municipalities of Rosita and Bonanza; mineral extraction has strongly shaped the history of the region.

The climate in the region is varied. Precipitation varies between 1800 and 3200 mm per year (MARENA 2003). The majority of rainfall takes place during the rainy season commencing in May and lasting until October. Heavy rains and damage from hurricanes are historically common in the region, although they are not as severe as elsewhere in the country.

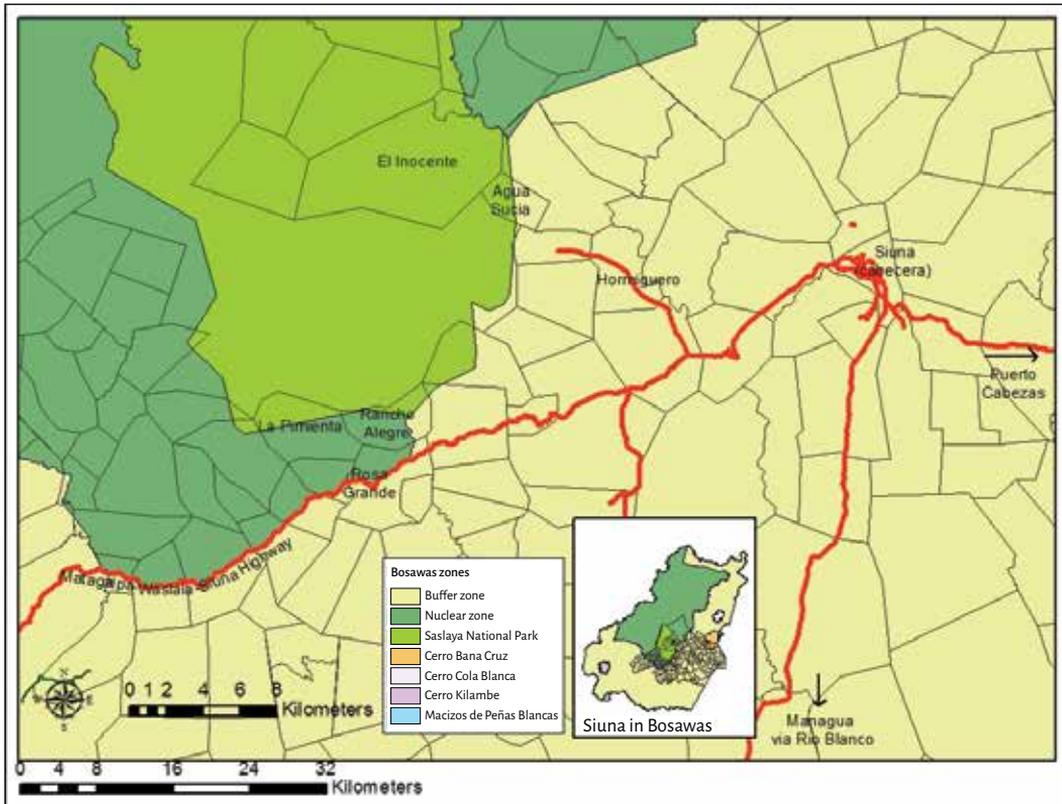


Figure 5.5 Map of the study communities, highways and Bosawas zones in Siuna.

According to a poverty analysis conducted in 2005 (INIDE 2008), Siuna is among the poorest municipalities in the country, with 75% of people surveyed identified as living in extreme poverty, ranking eighth worst in the nation. Given that Nicaragua is ranked as the second poorest country in Latin America and the Caribbean after Haiti, the region has some of the most marginalized communities in the Western hemisphere.

5.2.3 Study communities

Communities in Siuna surrounding Saslaya National Park were selected for this research to understand how, when and why deforestation has occurred in the region, where frontier advancement has stopped and where it is still occurring. Using GIS layers of Siuna's *comarcas* and Bosawas' boundaries, we identified 40 *comarcas* with territory in the southern nuclear zone of Bosawas below Saslaya National Park, nine *comarcas* with territory in the northern half of Saslaya National Park and three with territory in the nuclear zone north of Saslaya near Sikilta (indigenous Mayagna territory), indicating that nearly one quarter (52/190) of Siuna's *comarcas* have territory within the nuclear zone of Bosawas and/or Saslaya.

Because deforestation patterns do not reflect zoning and management regulations of Bosawas, selection of the six study communities was stratified based on timing of settlement and deforestation, in addition to ensuring selection of communities within different zones to understand why zoning was effective or ineffective in different areas.

Table 5.1 Location of study communities (*comarcas*) within Bosawas and Saslaya.

When the majority of deforestation occurred	Nuclear zone	50/50 nuclear and buffer	Buffer zone
Before 1986	–	Rosa Grande	Hormiguero
1986–2001	La Pimienta	Rancho Alegre	–
2001–11	El Inocente	–	Agua Sucia

Preliminary spatial analysis (prior to fieldwork) revealed different timing of deforestation depending on geographic location of the *comarca*, reflecting spatial patterns of human settlement and advance of the agricultural frontier. Following meetings with organizations and individuals working in the area, preliminary visits to eight communities, and meetings with community leaders, six communities were selected to focus ethnographic research. Of the six communities selected (see both Figure 5.5 and Table 5.1), the majority of deforestation occurred prior to 1986 in two communities (Rosa Grande and Hormiguero), deforestation started prior to 1986 but majority occurred between 1986 and 2001 in another two (La Pimienta and Rancho Alegre), and the highest rates of deforestation occurred between 2001 and 2011 in two (Agua Sucia and El Inocente).

5.3 Methodology

Utilizing a spatially defined landscape is a useful focal point for inter- or transdisciplinary research. According to Scherr et al. (2013) a ‘landscape’ is a socioecological system that consists of a mosaic of natural and/or human-modified ecosystems, with a characteristic configuration of topography, vegetation, land use and settlements that is influenced by the ecological, historical, economic, and cultural processes and activities of the area. In this study, the macro political boundaries of the study landscape is the municipality of Siuna, but we focus in on the *comarca* level (community-level political planning unit) for ethnographic fieldwork and restrict our study to communities in and around Saslaya.

Whilst there are some general agreements on what drives deforestation across large geographical regions, these broad-based regional drivers may not be appropriate for conservation or land-use planning policies, programs, plans or projects in specific places (Rudel et al. 2009). This research uses community accounts of historical settlement patterns and local perspectives of deforestation history, spatial analyses of land cover change, and secondary historical data and literature as its main tools to support what Lambin et al. (2003) refers to as a “narrative perspective” of the underlying drivers of deforestation in and around Saslaya National Park in Siuna. Given the importance of landscapes for food security as well as livelihoods, we interviewed participants about dietary changes to understand how diets were affected alongside community development and deforestation of the agricultural frontier. This inductive historical narrative approach was deemed appropriate given the paucity of data and information about the region particularly within the Mestizo communities. Settlers in the region are typically portrayed in the conservation media as illegal land traffickers, drug smugglers, loggers, colonists, ex-militia, cattle ranchers using extensive pasture and agriculturalists using expansive agricultural practices.

5.3.1 Ethnographic fieldwork

Research took place over 6 weeks between July and August 2013 and 8 weeks between May and July 2014. An interview schedule that covered basic characteristics of community, governance, population, land-use activities, social issues and development interventions prior to fieldwork was used for semi-structured interviews with community leaders. Leaders assisted in arranging FGDs with community elders (those who had lived in the community for the longest time). FGDs were designed to develop historical timelines of population change and land-cover change and identify drivers of land-use change from the community perspective. They were also used to better understand historical events, motivations for migration, dietary changes and food security issues that have developed over time or occurred during different time periods/events.

Additional key informant interviews were also held with farmers involved in cooperatives and other development interventions. Field walks were conducted in all communities to better understand land use throughout the community, farming practices, on-farm tree use, how and where fuelwood, thatch and timber were collected, community perspectives of park boundaries, and seasonal variations in activities. Elders, present and historical political leaders (i.e. leaders of health and education), and forest guards (*guarda bosques*) were interviewed to provide further detail on historical events/policies/programs as well as historical changes to park policy rules and enforcement. Seasonal calendars, wealth ranking and community-based mapping were used in Hormiguero, Rancho Alegre and Agua Sucia to garner further detail on poverty, livelihoods and farming.

Interviews were held with representatives from NGOs, government agencies, cooperatives and associations, international agencies for development cooperation, and academics from URACAAN. This allowed us to clarify events, historical data and policy-related questions. It also provided important insight on the role of development interventions in the landscape, what activities were occurring and how they functioned in relation to the land-use policies of Bosawas. These interviews were held in Siuna *cabecera* as well as in Managua.

5.3.2 Spatial analysis

Due to the limitations of available satellite imagery, the spatial analysis was conducted on a 2500 km² subset of Mount Saslaya and the surrounding area, which included the six research communities (Figure 5.6). Because adjacent scenes were not available for similar months in the years selected, the spatial area of the analysis does not cover the entire municipal boundaries of Siuna, nor does it cover the entire geopolitical boundaries of Saslaya or Bosawas. A spatial analysis of forest cover change was performed using Landsat imagery in 1986–2011, which was integrated into maps of forest loss and gain. Three Landsat surface reflectance files of one scene (path 16, row 51) were obtained from the United States Geological Survey (USGS) Landsat archive for 1986, 2001 and 2011. Atmospheric differences were corrected using the image multivariate alteration detection (iMAD) transformation (Canty and Nielsen 2006). Clouds, cloud shadows and water bodies were removed using a combination of supervised classification, manual digitization and masks provided

by the USGS. Overall cloud cover ranged from < 1% in 1986 to 24% in 2011. Vegetation indices were used to distinguish primary forest from deforested and disturbed areas. Several vegetation indices were derived and compared, including the disturbance index (Healey et al. 2005), the NDVI and the normalized burn ratio. Lastly, a threshold was used to classify forest and non-forest values from the disturbance index. Ultimately the normalized burn ratio provided the clearest delineation of forest disturbance, upholding previous findings by Stocks et al. (2007). A threshold was used to separate intact, primary forest from disturbed forest and generate binary classifications of primary forest extent. These classifications were used to produce maps of forest change between the two time periods, 1986–2001 and 2001–11.

Landscape change was analyzed at two spatial scales, at the level of the landscape as a whole and within different park boundaries. At the scale of the landscape, a basic Markovian transition model (Urban and Wallin 2002) was used to quantify forest change using 500 randomly sampled points on cloud-free areas. For the park boundary level analysis, a subset of three areas (the Bosawas buffer zone, Bosawas nuclear zone and Saslaya National Park) was sampled with 200 random points in each area. Map accuracy has not been assessed, though field data collected in November 2013 was used to inform classification.

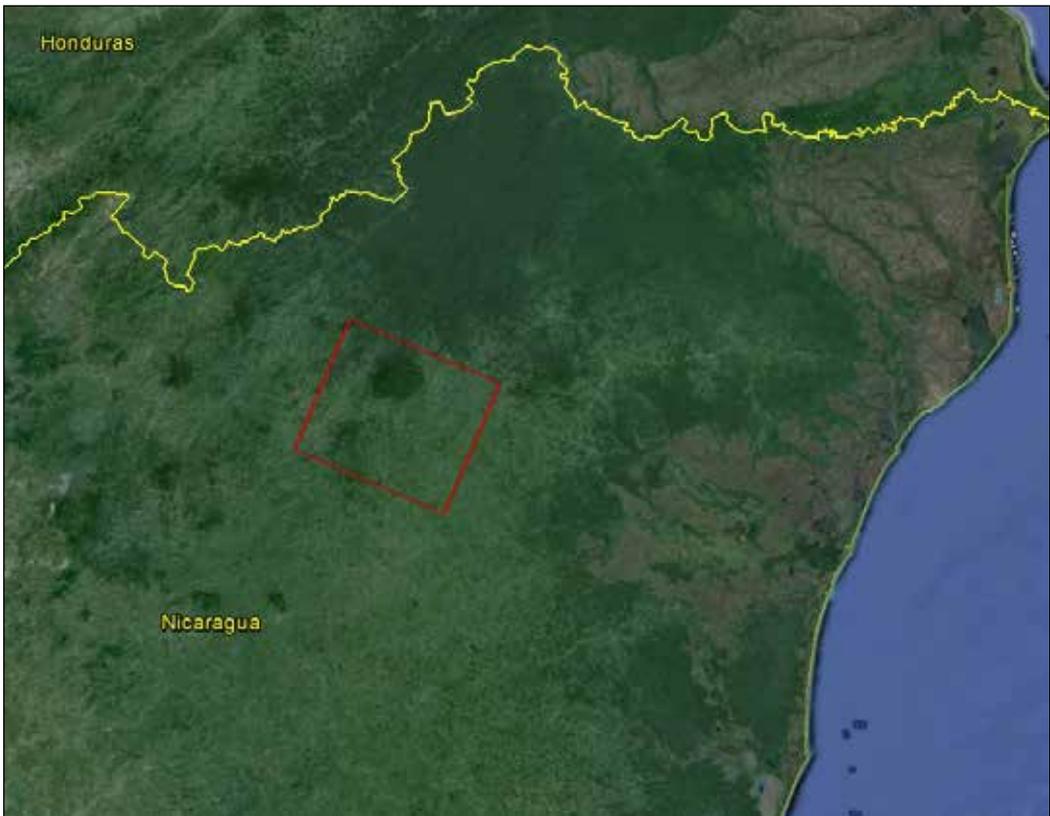


Figure 5.6 Spatial analysis study limits (Landsat scene path 16, row 51).

5.3.3 Historical review

In order to complement and triangulate information collected at the community level, secondary data and literature were used to provide supporting evidence and context via a historical narrative of the history of drivers influencing migrations into study communities.

5.4 Population growth and land-cover change

We collected community estimates of population (number of households) at 10-year periods in FGDs with long-term residents (Table 5.2). Communities with territory in the nuclear zone along the southern edge of Saslaya (Rosa Grande, Rancho Alegre, La Pimienta) noted that there were settlers in the region as early as the 1950s with small communities formed by the 1970s. Rosa Grande was settled rapidly in the 1980s as it was made a Sandinista (Sandinista Front for National Liberation or FSLN) cooperative during the Contra War, whilst other surrounding communities were evacuated (i.e. Rancho Alegre). Settlement in Hormiguero also began early, community members suggested that there were settlers there as early as the 1940s, and its population increased during the 1980s as it was also a FSLN cooperative. Agua Sucia and El Inocente (north of Hormiguero) are both newly settled communities; community members believe there were few settlers there before the 1990s. Agua Sucia and El Inocente's late settlement is reflective of their geographic location on the migratory route of the agricultural frontier that has expanded north of Hormiguero since the 1990s.

We calculated that the annual loss of primary forest loss inside the Bosawas nuclear zone fell from 2.43% per year in 1986–2011 to 1.6% in 2001–11. Figure 5.7 displays results from spatial analysis of deforestation in the study communities, revealing the heavy deforestation in the southern nuclear zone below Saslaya between 1986 and 2001. In 1986–2001, the Waslala–Siuna highway can also be seen, as well as the heavy deforestation within Hormiguero. Agua Sucia and El Inocente along with other communities northeast of Saslaya had some deforestation prior to 2001 but appear to be hot spots of deforestation compared to southern Saslaya between 2001 and 2011. This reflects the path of advancement of the agricultural frontier in Siuna through northeast Saslaya.

Communities reported in FGDs that forest cover in Rancho Alegre, Rosa Grande and La Pimienta (southern nuclear zone) began in the 1960s and 1970s and by 2000 more than 70% of virgin forest had been cleared in all three communities, with high rates of loss between 1990 and 2000 (Table 5.3). El Inocente community members estimated that forest clearing in the past decade in Saslaya was less than the period between 1990 and 2000. Spatial analyses report that deforestation in Saslaya increased from 0.13% between 1986 and 2001 to 0.95% between 2001 and 2011, which may be because the spatial area for analysis included communities to the northwest (where the frontier was expanding). Across the entire area included in the spatial analysis, forest loss over the 1986–2001 time period was 83,335 ha at a rate of 2.16%. Over the 2001–11 period it was 35,466 ha at a similar rate of 2.21%. The rates of forest loss in the buffer zone were similar in both time periods, at approximately 2.20%.

Table 5.2 Estimated population change of study communities from 1950 to 2014 as indicated by estimated number of households.

	1950	1960	1970	1980	1985	1990	2000	2014
Hormiguero	2	5	18–20	23	113	113	155	270+ (2010)
Rancho Alegre	2	2	5	12	2	54	65	108
Rosa Grande	2	7	12	15	100	100	150	200
La Pimienta (Sector 1) ^a	–	–	7	7	0–2	10	40–45	75
Agua Sucia	–	–	–	2	–	13	30	158
El Inocente (Sector 1)	–	–	–	1	–	1	40 ^b	200

a Population estimates are only for half the *comarca* as they were taken from 1 of 2 sectors.

b Population was reduced to zero in 2003 following evictions.

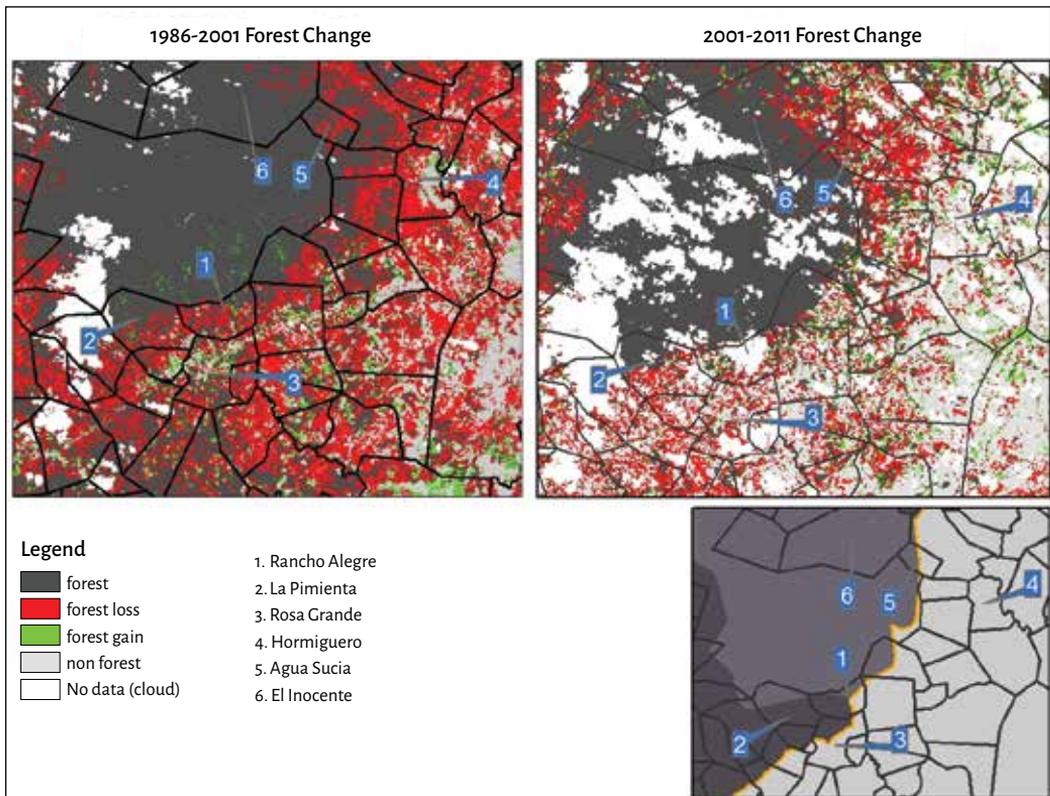


Figure 5.7 Forest cover change in the study landscape.

Table 5.3 Percentage land-cover change from 1940 to 2014 as estimated by study communities.

	1940 and 1950	1960	1970	1980	1990	2000	2014
Rancho Alegre	100% F	90% F	80% F 15% Ag 5% P	70% F 20% Ag 10% P	70% F 15% Ag 15% P	30% F 40% Ag 30% P	30% F 30% Ag 40% P
Rosa Grande	100% F	98% F 2% Ag	96% F 4% Ag	90% F 10% Ag	50% F 40% Ag 10% P	12% F 38% Ag 30% AgF 20% P	10% F 35% Ag 35% AgF 20% P
Hormiguero	100% F	100% F	95% F 5% Ag	90% F 10% Ag	85% F 10% Ag 5% P	50% F 25% Ag 25% P	15% F 35% Ag 50% P
La Pimienta	100% F	100% F	95% F 5% Ag	90% F 10% Ag	80% F 10% Ag	30% F 65% Ag 5% P	8% F 12% AgF 60% Ag 20% P
Agua Sucia Sector 2 ^a	100% F	—	—	50% F 20% B 30% Ag	50% F 20% B 30% Ag	5% F 93% Ag 2% P	5% F 5% Fs 85% Ag 5% P
El Inocente	100% F	100%F	—	—	70% F 30% Fs	10% F 30% Fs 60% Ag	5% F 80% Ag 10% P 5% AgF

Note: Ag = agricultural crops including rice, beans, corn, *musas* (plantain/bananas) and staple root crops; AgF = agroforest; F = primary old-growth forest; Fs = secondary forest; P = pasture.

a Missing data for Agua Sucia Sector 1.

5.5 Landownership and agricultural activities

5.5.1 Landownership

The social structure in Siuna can be modeled into the classes described by Enriquez (1991): the bourgeoisie or large landowners; the peasant farmer or *campesino* sector; and the agricultural proletariat. Land in Nicaragua is measured in manzanas (mz), which is equivalent to 0.7 ha. We have classified the bourgeoisie class in Siuna as those that own more than 100 mz (70 ha), the middle-class *campesino* sector are those who hold 20–100 mz (14–70 ha), the poor peasantry holding between 10–20 mz (7–14 ha) and the agricultural proletariat as those who own less than 10 mz (< 7 ha). The agricultural proletariat has little to no access to land and is frequently dependent on agricultural wage labor or other forms of labor for all or a portion of the year. Table 5.4 presents data on the area and number of farming families in each social class, as well as the division of land area between the different categories of farming landownership classes (compiled from data from the 2011–12 agricultural census for

Table 5.4 Social farming classes and landholding sizes.

Rural class	Holding size (mz)	Number of holdings	Proportion of holdings	Land area (mz)	Proportion of land area
Rural proletariat	< 1	115	1.85	20	0.006
Rural proletariat	1–5	499	8.05	1,747	0.504
Rural proletariat	5–10	687	11.08	5,507	1.588
Poor peasantry	10–20	1,093	17.63	16,744	4.827
Middle peasantry	20–50	1,839	29.66	62,665	18.065
Medium-sized landowner	50–100	1,185	19.11	86,324	24.886
Bourgeoisie	100–500	746	12.03	139,053	40.086
Bourgeoisie	> 500	37	0.6	34,824	10.03
Total		6,201	100	346,884	100

Siuna municipality).¹ These data reveal that the poor to middle class of peasantry (farms between 10–100 mz) are common and make up 66.4% of the farms and 47.7% of the land in Siuna. The bourgeoisie class (> 100 mz) make up only 12% of the farms but hold 50% of the land while the rural proletariat (< 10 mz) make up ~20% of the farms but hold less than 3% of the land. The 514 farming families that own less than 5 mz own less than 0.5% of the land.

Informants in Rancho Alegre, Hormiguero and Agua Sucia also discussed these patterns of landownership during community-based mapping exercises to understand landownership, property subdivisions, property consolidations and settlement patterns within the study communities. Each community had very few farmers with more than 100 mz, as well as few with less than 5 mz. Those who were reported to farm on less than 5 mz typically rented or borrowed this land from other farmers. Landownership patterns also revealed that people did not always live on their farms and that they may have multiple plots of land both within and outside the community that they owned or rented. Communities with road access typically had a row of houses and shops along the street/highway; farmers often had land elsewhere in the community for farming but preferred to live next to the road.

The majority of farmers in the study communities were middle-class, mixed-use farmers, cultivating basic grains and raising livestock, yet a significant portion had enough land for at least one cow. Large landholdings were uncommon; Rosa Grande reported ten farmers with more than 100 mz, Hormiguero reported two, Rancho Alegre identified one, and La Pimienta and Agua Sucia reported none. The bourgeoisie class of landowners were reported to live outside of the study communities in the *comarcas* of *Mutiwas*, *Union La Bu*, *San Marco Nasawe*, *El Guinea*, *Tazadna*, *Cooperana*, *Tadaznita* and *Santa Juania*. These

1 The 2011–12 census data was provided by the Ministry of Agriculture and Forests (MAGFOR).

large landowners were typically cattle ranchers who preferred flat terrain and access to water and roads. The steeper topography of the study communities (especially La Pimienta and Rancho Alegre) explains the lack of large-scale ranchers there.

Most communities reported that there was little land available for sale and that subdivision of family farms during inheritance was increasingly a problem. For example, one village leader explained that people are “sticking to their fathers land”; landowners who originally had 25 mz have since had children, for whom they have subdivided their land; their grandchildren are now faced with limited access to land. Access to affordable land is no longer possible for many young people in the study communities. To find cheap land, migrants today have to settle beyond the boundaries of Saslaya, which many communities try to prevent (discussed later) or they migrate to northern Saslaya beyond El Inocente (Figure 5.5), which is more than 8 hours from the nearest road.

5.5.2 Agricultural production

According to data from Nicaragua’s agricultural census for the 2010–11 growing year, 97% of households in Siuna with agricultural activity were producing basic grains. Half of the households had at least one permanent or semipermanent crop; the most commonly reported permanent crops were bananas/plantains (2188), followed by cacao (1068), coffee (699), sugarcane (256) and citrus (207). The adoption of permanent or semipermanent crops is still relatively limited compared to basic grains or pasture. Overall, only 3% of the total farmland was dedicated to permanent or semipermanent crops, while 14% and 28% was used for basic grains and fallow, respectively, and 52% was dedicated to natural and cultivated pasture.

The majority of the poor to middle peasantry (10–100 mz) were engaged in mixed crop-livestock production. Farmers grew rice, beans and corn (basic grains) along with several staple root crops, bananas and plantains. A portion of the land was set aside for pasture, depending on farmer preference and land area. Around the homestead, farmers planted and allowed natural regeneration of fruit trees, ornamentals, spices and herbs in *patios*. Poultry and pork were common domestic livestock and most middle peasantry owned at least one mule, used for transporting crops to market. Depending on farmer preference, education, cultural background and development support, they carried out coffee and/or cacao farming, typically in small-scale agroforests. As of June 2014, the largest cacao holding in Siuna was 18 mz.

Cacao agroforestry

The cacao industry in Nicaragua has grown substantially over the past 10 years, with the assistance of the Government of Nicaragua, international development organizations and the private sector. According to the International Cocoa Organization (ICCO), Nicaragua was among the seven largest fine flavor cocoa producing countries in 2010/2011. The industry has boomed in Siuna; the value of cacao has increased as global demand has exceeded supply for the last 10 years. The environmental benefits of agroforestry cropping systems have lead many conservation organizations to promote cacao agroforestry as the ideal land use in the buffer zones of protected areas, particularly for restored degraded areas (López Sampson et al. 2013). A steady increase

in development activities since 2007 has raised export levels of cacao by 300% with 2408 tons reported for exportation in 2012 (from 898 tons in 2007). Nationally, an estimated 7500 families were involved in cultivation on 11,000 ha of land, 50% of which were less than 3 years of age and were not in production (López Sampson et al. 2013).

GIZ initiated actions to improve the cacao value chain in Nicaragua in the early 1990s through Pro Mundo Humano, which had a collaborative arrangement with the multinational private enterprise Ritter Sport. GIZ, through *La Cooperacion Alemana*, has contributed to the development of the cacao sector with the stated aims of contributing to the sustainable management of natural resources and forests, and reducing the progress of the agricultural frontier, while encouraging better integration into the cacao value chain, enhancing value of agroforestry products and improving the incomes of farm families (López Sampson et al. 2013). In Siuna, GIZ provided technical assistance and capacity development to the Municipal Association of Cacao Producers, cacao cooperatives and producers in the management and design of cacao systems. Extension workers tended to work with medium-sized producers with secondary or remnant forest on their land that was underused, with the goal of turning them into productive agroforestry systems that incorporated fruit trees, timber species, *musas* (for shading and pollination of young cacao) and staple root crops (yuca and malanga).

Catholic Relief Services, supported by the Ford Foundation, worked with hundreds of new cacao farmers in Siuna. For several years they have been encouraging medium to large producers to convert a portion of their land to cacao agroforestry. At the time of research, they reported working with 700 producers in 13 communities in Siuna. A new project led by the Swiss Agency for Development and Cooperation (SDC) and the United Nations Industrial Development Organization (UNIDO) aims to expand the number of cacao producers in Siuna. Additionally, MLR, a Nicaragua enterprise associated with Norsteak, wanted to acquisition land from existing landholders and begin producing cacao in Siuna. Further details on their land acquisition and proposed production methods could not be obtained at the time of research. Smaller projects supporting producers with cacao agroforestry systems in specific communities were implemented by Bridges to Community in Rosa Grande and Rancho Allegre, and URACAAN conducted extension work in El Carao.

According to the 2010–11 agricultural census for Siuna, cacao was planted on 1068 holdings on a total of 1535 mz. Yet, according to a 2012 census of 692 farms from 16 different communities in Siuna (conducted by the Municipal Association of Cacao Producers), 1038 mz had plants of 1 year or more and only 573 were in production. Based on our observations, cacao production was rapidly increasing in Siuna. Communities with strong agricultural cooperatives (typically ex-Sandinista cooperatives) were recipients of the most development assistance. Care should be taken to aid families outside of cooperative kinship groups and communities that are difficult to access. Interestingly, dozens of farmers in El Inocente were also growing cacao despite a complete lack of formal assistance from any development or government agencies.

5.6 Historical drivers of settlement and deforestation

5.6.1 The first settlers, the gold mine, US exports and rebellion (1880–1934)

The first wave of settlers in Siuna arrived in the late 1800s and were predominately independent gold prospectors (*güiriseros*), who set up several small-scale nonmechanical mining operations in the headwaters of the Prinzapolka, Bambama and Waspuk rivers (Jastrzembski 2014). By 1896, the first police station was established in Siuna *cabecera* (Rocha 2001) and in 1897, entrepreneur José Aramburó built a steam-powered gold processing mill and founded the La Luz and Los Angeles Mining Company (Jastrzembski 2014). Siuna *cabecera* and the hamlet of Wany were the first modern settlements in the municipality of Siuna; Rocha (2001) reports 200 inhabitants in Wany as early as 1904. Prior to migrant settlement in Siuna, the Mayagna were the primary inhabitants of the region but were forced out, died of illness (or contamination from mine tailings) or underwent acculturation. Rocha (2001) notes the indigenous Mayagna were perceived to be at the bottom of the social ladder and were forced to work in the mine to repay debts generated from loans for seed, food, housing, tools and services provided by the mine.

In 1904, the La Luz and Los Angeles mine was purchased by an American James Deitrick, who had successfully obtained huge mining concessions for the northeast Atlantic coast from President Zelaya (Gismondi and Mouat 2002). Deitrick's activities brought in Pittsburgh investors with close ties to the political elite in Washington, DC and in 1909 the mining company supported a rebellion against President Zelaya who had implemented policies that were no longer favorable to foreign resource and agro-export industries (Gismondi and Mouat 2002; Jastrzembski 2014). President Zelaya resigned in 1911 but his designated replacement was forced out of office with US pressure and replaced by US-backed Adolfo Díaz, the former secretary of Siuna's gold mine. The US military officially occupied Nicaragua in 1912 – remaining until 1933 – in order to manage rebellions against Díaz, protect interests in export commodities and ensure

Table 5.5 Summary of key historical drivers/events of land-use change in Siuna (1904–34).

Year	Drivers of land-use change	Impact on Bosawas' resources
1904	Siuna gold mine established	Employment opportunity pulls settlers into the region
1909–33	US military occupies Nicaragua	Timber and gold extraction benefits foreign companies, little invested back into local economy
1927–34	Augusto Sandino leads revolutionary civil war against the United States	Conflict driven by US occupation. Impact on land use unknown
1928	Siuna gold mine is destroyed	Loss of jobs, switch to subsistence farming, hunting and fishing
1929–34	Great Depression leads to collapse of agro-export industries and economic recession	Increase in subsistence farming, hunting and artisan gold mining

that the proposed interoceanic canal through Nicaragua would not be constructed by any other nation (Jastrzembski 2014). These events were part of the famous region-wide “banana wars” where Western economic interests in agricultural, forest and mineral export commodities in Latin America and the Caribbean largely drove conflicts (Langley 2002).

By 1926, US exports out of the Atlantic from the United States Bluefields consular district (comprising the eastern half of Nicaragua) were valued at USD 3,801,122. Products included: mahogany (19,801,609 board feet at USD 1,566,586), Spanish cedar (4,845,719 board feet at USD 320,914), bananas (2,558,805 bunches at USD 1,565,260), gold (21,787 ounces at USD 186,378), coconuts (737,345 at USD 20,537), rubber (34,264 lb at USD 14,912) and miscellaneous goods at USD 123,535 (American Consulate 1926). The US also dominated import markets into the Atlantic; 85% of imports to the region in 1926 arrived from the United States (American Consulate 1926). Because Siuna was 300 km away from the Atlantic Coast, it is unlikely that much of the timber exported from Bluefields would have been sourced in Siuna. Nonetheless, timber harvesting for house construction and mine operations would have begun during this period.

The US occupation of Nicaragua and foreign ownership of Nicaraguan land and resources were primary drivers behind a national guerrilla war and *campesino* rebellion, famously led by Augusto César Sandino between 1927 and 1933. During this period, conflict and infrastructural damage was a frequent occurrence as Sandino and his supporters strategically dismantled many foreign resource extraction, forestry, agro-export and shipping operations. In 1928, Sandino and his armed supporters wrecked the surface plant of the La Luz and Los Angeles mine in Siuna and a series of raids/clashes occurred afterwards (see Jastrzembski 2014). Sandino viewed the American-owned mine as a symbol of betrayal to the Nicaraguan people and their land. The destruction of the mine reflected the antagonism toward the American presence in Nicaragua (Gismondi and Mouat 2002). The Sandino rebellion continued until 1933, when the US military was forced to withdraw due to the high costs of military operations during the Great Depression.

The Great Depression also caused a decrease in the price of export commodities and a surge in unemployment as export industries collapsed. Given the importance of the export economy (i.e. bananas, coffee and cotton) to peasant livelihoods at the time, the Great Depression is suspected to have been a major driver of deforestation and wildlife depletion as many people turned to subsistence farming, hunting and fishing in order to cope during those difficult years. In Siuna, the jobless mineworkers may have also supported themselves through artisan gold mining, using gold as a currency to trade against food and other goods. Those that turned to farming are likely to have moved into forested areas, but it is difficult to estimate drivers of deforestation without additional evidence. For example, it is unknown whether steamboats continued to import goods from the Atlantic up the Prinzapolka River to Siuna during this time. Table 5.5 summarizes the aforementioned key historical drivers/events of land-use change from 1904 to 1934.

5.6.2 Urban and rural growth: A period of prosperity (1935–1968)

In 1936, Anastasio Somoza Garcia – the head of the National Guard – successfully implemented a military coup, assassinated rebellion leader Sandino and seized presidential power through rigged elections (Walker 2000). This succession marked the beginning of the Somoza family dynasty, which included successive leadership of Anastasio Somoza Garcia’s sons Luis Somoza Debayle (1956–63) and Anastasio Somoza Debayle (1967–72 and 1974–79). According to Enriquez (1991) the Somoza family ran the country like their own private estate or “medieval fiefdom” so that by the 1950s, Anastasio Somoza Garcia had become the wealthiest man in Central America. The Somoza family earned their fortune by acquiring businesses and properties in the transportation, dairy, rum and beef industries, holding immense power over various components of the agro-export value chains and markets. Many of the family’s properties and businesses were acquired at very low costs and through corrupt and coercive measures (Enriquez 1991). The Somoza dynasty also earned money through voluntary taxes paid directly to them by mining companies, providing impetus for new government support of foreign mining investments (Enriquez 1991).

5.6.3 The re-invigoration of Siuna’s mine

In 1938, two years after the Somozas’ succession of leadership and after a decade of abandon, Pittsburgh- (Tonopah) and Toronto-based (Ventures) mineral extraction companies purchased the Siuna gold mine. Jointly they formed a new company know as La Luz Mine Limited. Canadian mining entrepreneur Thayer Linsley – the father of mining giants Falconbridge Ltd., Ventures Ltd. and Frobisher – was the president of all three companies (Jastrzembski 2014). Investments made by the new ownership resulted in significant profits for the company, a proportion of which was reinvested in Siuna’s infrastructure. This resulted in Siuna’s transformation from a mere mining camp to a corporate mining town (Jastrzembski 2014). La Luz Mine Ltd. was responsible for the construction of a hydroelectric dam in 1942, which brought electricity into the town. The company constructed local roads, which facilitated vehicular transport from the hydroelectric dam to Siuna *cabecera*, as well as to river ports on the Prinzapolka River and to the town of Rosita, where a second mine was in operation (Jastrzembski 2014). An airport was established, reducing travel time to the region from weeks to hours, dramatically influencing the rate at which goods, personnel and equipment could be imported and exported, and greatly improving the mine’s efficiency.

The reinvigoration of the Siuna mine offered new opportunities following the economic hardships of the Great Depression (Crawley 2007). By 1941 the company employed 1073 people (Jastrzembski 2014). The mine drew in hundreds of Mestizo, Creole and indigenous migrants into Siuna, forming the diverse cultural heritage of the region. Jastrzembski (2014) reports migrants to Siuna in the 1940s had origins in La Cruz, an Atlantic coast town off the Rio Grande River (many of whom were likely to be Miskitu), as well as the western agricultural highlands of Boaco, Chontales, Matagalpa and Nueva Segovia. Migrants typically traveled by trails. According to an archived report from 1933 (US Marine Corps 1933), there was a trail (footpath/mule path) from the Atlantic to the Pacific that started in Puerto Cabezas, passed through San Luis (present location unknown), Pis Pis (Bonanza), Siuna, Wany and Iyás, and then branched off to Jinotega and Matagalpa.

5.6.4 World War II, agro-estates and Somoza's agrarian reform

While Siuna was experiencing new growth and prosperity, Nicaragua's agro-export industries (especially coffee, cotton and bananas) continued to struggle from late 1930s throughout World War II. Nicaragua's main trading partners during this period included Germany, Britain, the United States and Japan (see Crawley 2007), and as such its export prices and trading partners were dramatically affected by international politics. However by the 1950s, a cotton boom spurred by demand during the Korean War created a resurgence in the agro-export industry and generated wealth outside of the Somoza family. This wealth was primarily obtained by a bourgeoisie capitalist class of cotton producers and not by small- or medium-sized farmers. The national acreage of cotton multiplied fivefold between 1950 and 1955, accounting for 39% of foreign exchange earnings (Enriquez 1991). The cotton industry expanded by buying out or forcibly evicting small and medium farmers located on lands ideal for cotton cultivation, typically farms previously used for cattle rearing and subsistence production. Evictions were easily facilitated due to the lack of legal land titles held by the smaller farmers (Enriquez 1991). Cotton production was key for making agro-export production the base of Nicaragua's economy. It changed the social structure and had a profound impact on labor and class relations. According to data presented by Enriquez (1991), by 1963, 40% of land was owned by 1.5% of the farming families, all of which were 500 m² or greater in size. Conversely, approximately 50% of farms were less than 10 m² in size, accounting for approximately 3% of the agricultural land area. Coffee production was similarly important during this time period with the number of acres under coffee cultivation doubling between 1950 and 1963, leading to further expropriation of land (Enriquez 1991).

Sugar, tobacco, bananas, seafood and beef production also expanded in the 1950s and 1960s. The beef industry had existed since colonial times, exporting tallow, hides and meat abroad. However in the late 1960s, beef production increased substantially, primarily to support national demand as well as beef exports driven by America's fast food industry (Enriquez 1991). Nicaragua's cattle herd grew by 46% between 1963 and 1971, cattle exports doubled and the area occupied by pastures grew by 31% during the same period (Enriquez 1991). This expansion of large agro-export farms pushed small and medium farmers off their land, forcing them to establish farms on more marginal terrain, and pushed migrants into frontier forests. These land acquisitions (via negotiations and coercion) displaced farmers throughout the Pacific from the 1930s to the 1960s, widened class divisions and caused growing resentment amongst those impacted (Stanfield 1995).

To ease rural opposition caused by the loss of agricultural land, Somoza promoted settlement in Nicaragua's interior forests. Somoza's agrarian reform provided peasants with free land titles for the first 50 m², allowing additional land to be purchased at very low prices (one informant equated this being equivalent to USD 1/m² today). As such, many of the original settlers in Siuna have large landholdings. The extent to which the initial settlers who claimed these large properties actually received titles and paid for the land is not entirely clear. For example, Rancho Alegre community members reported that prior to the 1980s, just one person owned the entire community; portions of the land were subsequently sold to incoming settlers. Similarly, an elder from Hormiguero reported that his family and three others purchased portions of land from a farmer who owned more than 2000 m². Nonetheless, the first settlers were a mix of poor peasants with at least 50 m² and wealthier landowners with > 500 m².

5.6.5 Rural resource extraction and farming in study communities

The first agrarian settlers in Siuna were not alone; people engaged in forest resource extraction enterprises had reached Siuna and many of the research communities by the 1940s. *Chicleros* (*chicle* harvesters), *uleros* (rubber harvesters) and *banqueros* (timber harvesters) established camps in several of the study communities as well as in other rural communities in Siuna. The earliest record through oral history of their presence was the 1940s but it is possible that they might have arrived earlier. Timber extraction was reported along the trail from Waslala–Siuna including in Rosa Grande, as well as along the road to Hormiguero and the banks of the Prinzapolka River into Agua Sucia. Mahogany and Spanish cedar were harvested primarily for export to American and European markets led by American companies. Until the 1950s, timber harvesting was entirely by hand axe, which was later upgraded to handsaw in the 1960s. By the 1970s, the chainsaw was introduced. This technological evolution was important in reducing the time required for harvesting and the rate at which forest clearing for agriculture and timber could occur. The species harvested for timber diversified beyond cedar and mahogany as infrastructure and construction projects in Siuna *cabecera* expanded. An elder in Hormiguero noted that a large amount of wood harvested from the community went to supply the La Luz mining company.

Rosa Grande and Hormiguero were the first of the six study communities that were settled. At the time of settlement, less effort was put into crop production than today, as diets were heavily supported by bushmeat, fish and food provided by commissaries and labor at a resource camp could be traded for food. Those who cultivated crops practiced swidden cultivation, clearing forest for planting basic grains where they would be cultivated for 2 years before moving on to a new plot of forest. Fallows (*rastrojo*) were used again for cultivation of basic grains after 4 years or were converted into bananas/plantain (*musas*) fields. Since landholdings were large at the time (at least 50 mz) only a portion of the farm was used for agriculture, the rest remained as forest. Many wealthier farmers also had cattle but they were mainly used for subsistence dairy production.

5.6.6 The collapse of the Siuna mine

After approximately 30 years of growth and prosperity, Siuna's economy slammed to a halt in a matter of days. On 12 August 1968, heavy rains caused the hydroelectric dam on the Yy River supplying the mine to collapse under the weight of the floodwater. The floods damaged multiple villages (none of the six study communities) leaving many homeless (Jastrzembski 2014). Without an affordable source of electricity for water pumps, the mine was flooded and operations ceased. The Siuna mine was abandoned by the company and all equipment was moved to Rosita where the company subsequently focused their operations (Jastrzembski 2014). In the 30 years of production by the La Luz mining company, over 15.42 tons (17 million imperial tons) of ore and 1.8 million ounces of gold were extracted from Siuna (Jastrzembski 2014). The closure of the Siuna mine had a dramatic impact on Siuna's economy with more than half the workers becoming unemployed instantaneously (Jastrzembski 2014). Those who didn't leave Siuna (many left for Rosita), found work through artisan gold mining as gold could still be sold or traded for goods and services (Jastrzembski 2014). Others turned to subsistence farming to support basic dietary needs. Fur trading and timber harvesting may have also provided income sources, but whether the mine's lumber mill continued to operate from 1968 to the 1980s is unknown.

5.6.7 Saslaya's creation

Three years after Siuna's mine collapsed, Nicaragua's conservation movement began making strides toward creating a national system of protected areas. Nicaragua's second national park, Saslaya National Park, was created by executive decree in September of 1971,² encompassing Saslaya mountain and several other adjacent peaks in the mountain range, originally covering a total area of 118 km². According to Ryan (1978), Saslaya was created due to the pressures from a concerned group of citizens. These citizens likely observed an increase in rural settlement, hunting and timber extraction following the collapse of the mine, and sought to protect it for personal reasons (i.e. hunting/food supply and water sources), as well as environmental ethics.

5.6.8 Managua earthquake and drought

A year after Saslaya's creation, Nicaragua suffered a catastrophic earthquake that leveled massive sections of Managua, the nation's capital. Kates et al. (1973) reports that of an estimated 420,000 people in the city, 1% died, 4% were injured, 50% of previously employed became unemployed, 60% fled the city and 70% were left temporarily homeless. On a national scale, 10% of the industrial capacity, 50% of the commercial property and 70% of the government facilities were made inoperative (Kates et al. 1973). To make matters worse, the country simultaneously experienced the worst drought in over a century (BBC n.d.) causing massive production losses for agrarian subsistence and export farmers. The droughts coupled with the earthquake triggered another wave of migration toward the country's rainforests, where affordable land and access to water were a major pull factor. A key informant in La Pimienta reported that they had left the western highland community of Dario in the 1970s for Siuna after 3 years of drought, which forced the family to sell their land and move east to the wetter and more fertile forested area.

5.6.9 Corruption, rebellion, terror and displacement

The political situation in Nicaragua took a turn for the worse when the president Anastasio Somoza Debayle misappropriated earthquake relief aid by funneling it through family-owned banks, hiring only family-owned construction companies, and prioritizing rebuilding on Somoza family land and property, thereby profiting immensely from the calamity (Montgomery 1980). This corrupt use of funds fueled an already growing public dissatisfaction with the regime. Support for the Sandinista National Liberation Front (FSLN) and the peasant guerrilla army they supported grew. In an effort to repress the opposition, Somoza's National Guard undertook a siege of terror in the north central highlands of the Pacific between 1975 and 1976. Search and destroy missions in rural communities led to the destruction of houses, crops and livestock and various human rights abuses (Enriquez 1991). An estimated 80% of the rural population in the northwestern countryside was uprooted and displaced during this period, many into temporary refugee camps (Brown 2015) or remote forested areas such as Siuna.

2 Created by Executive Decree #1789 signed by Somoza and published in Gazette No.78 on 2 April 1971 (Asamblea Nacional de la República de Nicaragua 1971).

In January 1978, Joaquin Chamorro, the editor of *La Prensa* newspaper and conservative activist against the military dictatorship, was assassinated. His family claimed Somoza had ordered the killing. Joaquin Chamorro's death catalyzed a massive popular uprising in major urban areas around the country (Zimmerman 2000; Walldorf 2008). The government responded by instating martial law and attacking areas of uprising with aerial bombing and artillery attacks leading to an estimated 5000 deaths (Zimmerman 2000; Walldorf 2008). Social and economic conditions in the country reached desperation, causing 50,000 refugees to flee to Honduras, Costa Rica and El Salvador (Zimmerman 2000). This insurrection must have been one of the most barbaric military attacks against a civilian population in the Americas (Sklar 1988).

5.6.10 The revolutionary war

The Nicaraguan mass-based uprising was eventually successful in ousting the Somoza regime on 19 July 1979, ending the 42-year reign (Kallen 2009). The social cost of the revolution was steep with an estimated 50,000 casualties (Nolff 1982), 600,000 homeless (Kallen 2009) 10,000 wounded and 150,000 internal or external refugees (Fitzgerald and Grigsby 2001). The material damage of the war was an estimated USD 481 million, raising external debt to USD 1.65 billion (Nolff 1982).

5.6.11 Settlement and migration 1970–79

The years of property loss, drought, poverty and oppression, followed by a revolution and barbaric military campaign were key factors pushing migration into agricultural frontiers during the late 1970s. The Somoza regimes legacy of greed, corruption and military oppression created a dire situation amongst the socially repressed peasant class, which was characterized by low income, illiteracy, malnutrition and high mortality rates (Zalkin 1990; Walker 2000). Much of the rural population was comprised of migrant farmworkers, squatters and sharecroppers living in poor conditions (Walker 2000). The harsh living conditions in rural areas triggered migration to urban areas (Walker 2000), as well as rural–rural migration to the agricultural frontier.

By 1976, the journey to Siuna from the Pacific could be completed by vehicle (bus or truck) as the Somoza Government completed the Matagalpa–Waslala–Siuna highway. This was the first time Siuna had a land-based vehicular connection to the Pacific. Migrants arrived and established farms and large landowners began selling plots to incoming migrants. By the start of the 1980s, settlements were established within all study communities (with the exception of El Inocente), and forest clearing was well underway. Farms and houses located along the new highway were established earlier; property with road access was coveted. The road also provided basic grain producers and cattle ranchers with a means to sell produce, shifting the economic opportunities available in rural communities and founding rural Siunas agrarian society. Until improvements in the 1980s, the road was rudimentary; it took 1 week to get to Siuna from Matagalpa (which today is an 8–10 hour drive). Table 5.6 summarizes the aforementioned key historical drivers/events of land-use change from 1935 to 1979.

Table 5.6 Summary of key historical drivers/events of land-use change in Siuna (1935–79).

Year	Drivers of land-use change	Impact on land-use change
1936	Somoza dynasty dictatorship begins	
1938	La Luz Gold Mine purchased	Surge in migrants pulled by opportunity for employment
1938–44	WWII	High price volatility due to WWII international politics hurts Nicaraguan farmers and triggers migration
1950–79	Somoza dynasty policies	Land appropriation by Somoza family and bourgeoisie class for coffee, beef and cotton pushes poor farmers into agricultural frontier Land reform policies provide land titles for first 50 mz pulling settlers in the agricultural frontier
1968	Siuna mine collapses	Devastates local economy, unemployed turn to agriculture, artisan gold mining, hunting and timber extraction
1970s	Introduction of the chainsaw	Likely increased rate of timber extraction and rate of land clearing for agriculture
1972	Earthquake devastates capital of Managua	Many leave city for rural areas, including agricultural frontiers
1972–75	Droughts	Migrants pushed into agricultural frontier in search of wetter climate
1975–76	Seige of terror in Pacific highlands	Migrants pushed to Siuna for safety
1976	Matagalpa–Waslala–Siuna Highway made suitable for motorized vehicles	Migrants pulled by improvement of region for trade and settlement
1977–79	Rebellion, conflict and Sandinista revolution	Thousands displaced and thousands seeking land and retribution for decades of oppression

5.6.12 Agrarian reform and the Contra War (1980–90)

Following the revolution, an interim government ran the Nicaraguan State – the Junta of National Reconstruction. In 1981, FSLN leader Daniel Ortega assumed power following the resignation of the rest of the Junta. The new leadership immediately undertook actions toward implementing agrarian reform with the intention of reducing class-based inequity and improving the balance between production for export and domestic consumption, and thus improving the standard of living of the rural poor (Enriquez 1997). To do this, a massive campaign of land expropriation from wealthy landowners was undertaken. Approximately 3 million mz from nearly 6000 properties were confiscated; nearly one third was from the Somoza family and people with close ties to it.

According to Enriquez (1997), land redistribution and complementary policies were implemented in various stages. During 1979–81 the Sandinistas formed State farms (from the large private agro-export enterprises), massively extended the opportunities

for obtaining agricultural loans and began a limited distribution of land to collectively organized peasants (Enriquez 1997). Following the ratification of the 1981 Agrarian Reform Law, the land distribution process accelerated and land was primarily distributed to collective farming groups. In the mid 1980s, additional forms of land distribution offering benefit to more diverse groups were introduced (Stanfield 1995):

- *Cooperativas Agrícolas Sandinistas* (CAS) – title given to a group of farmers expected to form collective farming enterprises, sharing land, labor, produce and income
- *Collectivos de Trabajo* (CT) – title given to smaller familial groups of farmers also expected to farm collectively
- *Cooperativos de Surco Muerto* (CSM) and *Cooperativas de Crédito y Servicio* (CCS) – group title given to individual farmers who farmed individually
- Individual titles and indigenous titles.

Complementary policies were introduced by the Sandinistas including: guaranteed state prices for crops, state marketing services, bank credit, technical assistance, support for peasant organizations, agricultural research, and social programs for literacy and health care (Zalkin 1990). However as Enriquez (1991, 1997) reveals, these goals were contradictory to the agrarian class structure that had developed between basic grain producers and agro-export industries. Historically, the marginalization of basic grain producers (by Somoza) had required them to work seasonally on agro-export estates (i.e. coffee, cotton and cattle ranches). Because the Sandinistas now provided the basic grain producers with access to credit, seeds, training, education and food rations, many farmers chose not to work on the coffee and cotton export estates as basic needs were met. According to Enriquez (1991), “the increase in food security that resulted from the redistribution of credits undermined the fundamental motivation that had led these workers to the harvest in the past – hunger.” This and several other factors led to decreased production of export-crops and significantly inhibited the growth of the agro-industrial sector during the 1980s.

The acquisition of cooperative land by the Sandinistas also caused numerous problems for middle and poor peasants wishing to hold onto their titles. Because cooperative land needed to be spatially connected, several adjacent farms needed to be acquired if the holding wasn't large enough. A key informant reported how he was jailed for several months after refusing to hand over his land to one of the cooperatives. Another told us how one cooperative took a portion of his father's land and they could do nothing about it. Thus, in addition to the dissent the Sandinistas faced from the wealthier classes who had their land expropriated, less wealthy peasants were unhappy with the acquisition process. Many others were unsatisfied with the distribution process having not received land despite Sandinista promises.

5.6.13 The counter-revolutionary force: The contras

A counter-revolutionary force grew rapidly following the Sandinista revolution. Their local resistance efforts were nearly dismantled by the Sandinista military but support from the United States' Reagan administration aided in the regrouping and facilitated links with exiled Somoza National Guards in Honduras. They formed the Nicaragua Democratic Front (FDN), a counterrevolutionary army known as “the contras” (Enriquez 1991). The FDN was armed and supported logistically and financially by the US (i.e. the

Iran-Contra Affair), whilst the Sandinistas were supported by Communist bloc countries. The formation of the FDN was part of a wider US strategy to overthrow the Sandinista regime, as it was perceived as a threat to American geopolitical interests in Central America in the context of the Cold War. In 1982, civil war broke out again, marking the beginning of the famous Contra War, which lasted until 1990 (Enriquez 1991).

5.6.14 The Contra War in Siuna: Evacuations and cooperatives

In order to defend certain rural areas against heavy contra activity, the FSLN decided that rural areas would need to be cleared of the agrarian population. In 1981, peasants throughout Siuna were evacuated from their farms; some left the country, some returned to their areas of origin, some joined the contras and others were integrated into Sandinista agricultural cooperatives. Because of the war, the Sandinista cooperatives were transformed into armed peasant self-defense cooperatives (*cooperativas de auto-defensia*), a strategic military defense tactic of the Sandinistas. Peasants who tried to remain on their farm were under great risk; being kidnapped by the contras and taken to Honduras was the most commonly reported risk. Arnson and Holiday (1991) provide further details of how the war wreaked havoc on the civilian population as the contras engaged in murder, torture and kidnapping of any civilian presumed to be supporters of the Sandinistas. Brody (1985) reports that the road connecting Siuna and Matagalpa was the scene of many ambushes by the contras on trucks carrying food shipments, health workers and schoolteachers. Additionally, entire communities were invaded and forcibly conscripted into the resistance forces (Phillips 2004).

The FSLN created at least 14 CAS cooperatives, which served as *cooperativas de auto-defensia* in Siuna to which peasants were evacuated, encouraged and coerced to join. We identified historical cooperatives in Hormiguero, Rosa Grande, Las Quebradas, El Ocote, Ully, Floripon, Union-Labu, San Pablo Asa, Wany, Cooperna, Mongallo, Tadazna, Las Delicias and El Torno. A key informant estimated that there were approximately 100 smaller cooperatives (CC, CCS, CSM and CT types) in Siuna as well. The Hormiguero cooperative was the second largest in Siuna (after La Bu) holding collective titles for approximately 3500 m² for its 200 family members. They produced basic grains, roots and sugarcane, had ~200 head of cattle, and reported harvesting timber for the mine, which was again in operation during the 1980s having been taken over by the Sandinistas – although operations were not very lucrative and continued only until 1984 (Jastrzembski 2014).

The Las Quebradas coop (below La Pimienta) held 1728 m² for 77 families. The Rosa Grande coop was also one of the largest and productive. Rosa Grande community members reported that most deforestation occurred during the 1980s as the population grew from 15 to 100 households and forest cover decreased from 90% to 50%. The CAS cooperatives continued their collective farming activities throughout the 1980s, receiving health care, education, seeds, credit and food packages. The government purchased produce from the cooperatives, reportedly paying good prices for it. Conditions in many cases were better in terms of food and livelihood security in cooperatives but many coops were continuously subject to attacks by contra soldiers. By mid 1986, an estimated

20,000 families and > 100,000 individuals had been moved to cooperatives (Zalkin 1990). According to a participant who was part of the Hormiguero cooperative:

Yes. It's to say that when it was the war...we had to...be evacuated. In my case, the San Jose Bocay estate was not sold, it was dumped, we lost it. They evacuated us, left us there [unclear where 'there' is]. Then, the government came up with the idea to save the lives of the country persons, of the producers who used to be in the deep forests, they [the FSLN] took them out so that the opposition wouldn't kill them...Then, they threw us in groups, in settlements like Hormiguero. They handed out programs, gave them land and introduced agricultural programs.

This person raises an important issue for further research relating to post-war land tenure. Many people who were forced to evacuate their land and join cooperatives were unable to reclaim their land (which was outside of the cooperative) following the war. This may have been due to the fact that the Sandinistas adapted the agrarian reform law in 1986 to allow for the confiscation of any size farm that was idled land or for various other reasons such as occupation/confiscation by armed ex-contra soldiers or other landless persons (Stanfield 1995).

5.6.15 Peasant farmer land seizures

In addition to evacuations and resettlement led by the FSLN, the mid-1980s was also filled with landless peasants organizing and claiming land by force. Ryan (1995) discusses several instances where peasants decided not to wait for Sandinista land handouts and cooperative titles, and instead seized farms and immediately began planting corn to demonstrate ownership. Many of these seizures resulted in the ex-post legalization of land seizures and the granting of titles to individual peasants. These activities occurred in part due to historical repression and landlessness, war and a mounting economic crisis, which threw the agrarian class into deeper poverty.

5.6.16 The late 1980s economic crisis

The overall cost of the Contra War including physical damage, lost production, displacement of people from war zones and interruption of energy supplies was estimated at USD 2 billion (Leogrande 1996). At the end of the 1980s, Nicaragua's already dire economic situation worsened. In 1986, GDP contracted by 5.9% and inflation reached 320% (Leogrande 1996). One year later, it soared to 1300%. In an effort to reduce inflation, public spending was reduced causing a severe recession. By 1988 the economy contracted by 15% and hyperinflated to 33,600% rendering the currency worthless and reducing trade to simple bartering (Leogrande 1996; Enriquez 1997). The economic crisis forced those who could farm to try to survive from one year to the next while the value of their harvests decreased and the prices of other goods increased. According to Enriquez (1997) most peasants were unable to farm without 100% of the costs being assumed by the State through agricultural credit.

The economic crisis was a result of various factors including: problems with the Sandinista development strategy (see Enriquez 1991, 1997), wartime expenditures and economic policies imposed by the US Government during the 1980s. The Reagan administration suspended economic aid to Nicaragua (Leogrande 1996), used its veto power or political influence to block numerous loans to Nicaragua (including from the

IMF, the World Bank and the Inter-American Development Bank), and pressured other countries not to make bilateral loans (Leogrande 1996). In 1983, the United States reduced Nicaragua's share of the US sugar quota by 90% and escalated the economic sanctions by imposing a full trade embargo in 1984 (Leogrande 1996). Although the embargo was found one year later to be in violation of international law by the International Court of Justice,³ the United States continued the embargo for four more years (Anon. 1989). This embargo had significant impacts on Nicaragua as 30.4% of its trade in 1980 was with the US. That reduced to 14.9% in 1984, forcing Nicaragua to increase trading partnerships with Japan, Western Europe and the Soviet bloc, and to incur higher transport costs to the new markets (Leogrande 1996). The main exports affected were bananas, beef, shellfish, tobacco and sugar (Leogrande 1996). The economic sanctions imposed by the United States had a negative impact on various sectors, especially agro-export production as delivery of imported fertilizer, pesticides, irrigation equipment and industrial machinery parts were delayed (Anon. 1989; Leogrande 1996).

5.6.17 Resettlement, road construction and Hurricane Joan (1986–89)

Rancho Alegre study participants reported that people were allowed to return to the community in 1986 due to reduced Contra Activity in the region. A few new migrants

Table 5.7 Summary of key historical drivers/events of land-use change in Siuna (1981–90).

Year	Drivers of land-use change	Impact on land-use change
1980–90	Sandinista agrarian reform – millions of hectares of land appropriated and redistributed and State takes ownership of large agro-export farms and employs millions Land seizures by peasant groups	Low impact in Siuna at this time but when land is redistributed (post-1990) back to original owners, landless migrants move to agricultural frontier
1981–90	Contra War – Wartime evacuations of rural peasants into agricultural cooperatives	Forest regeneration occurs in scattered areas where peasants abandoned but deforestation increases in agricultural cooperatives, which were highly productive farms producing food for the state during wartime
1985–90	US economic blockades halt foreign aid, prevent international loans and impose a trade embargo (breaking international treaty) – hyperinflation, recession and devaluation of currency	Increases hunting, fishing, artisan gold mining, timber extraction and subsistence farming, which continued to have an impact into the mid to late 1990s
1986	People in Siuna begin returning to their farms	Clearing of regenerated forest (fallow) and primary forest
1987	Highway (suitable for motor vehicles) between Waslala and Siuna completed	Surge in migration and settlement
1988	Hurricane Joan	Forest degradation, economic loss to crops increases pressure on wild resources

3 According to Article 292(7) of the International Court of Justice, 1986: Case Concerning Military and Paramilitary Activities in and against Nicaragua, the court voted in favor of the decision that the United States embargo breached obligations under Article XIX of the 1956 Treaty of Friendship, Commerce and Navigation between the US and Nicaragua.

also arrived at this time. When people returned to their farms, agricultural fields had turned to fallows outside of cooperative farming communities (i.e. Rancho Alegre and La Pimienta).

This had a positive effect on soil quality and wildlife populations, which had reportedly thrived in the fallow agricultural fields (the rodent population was reported to be much higher when they returned). Just as settlers were returning, in 1987, the Sandinista Government improved the Matagalpa–Waslala–Siuna highway, significantly shortening the journey from a multi-day to a day trip by vehicle. This aided imports and exports of coops along the highway, as well as migrant travel. Hurricane Joan was reported to have caused flooding, landslides, crop and infrastructural damage in 1988 in Siuna, exacerbating already difficult conditions for returning farmers. Table 5.7 summarizes the aforementioned key historical drivers/events of land-use change from 1981 to 1990.

5.6.18 Demobilization, resettlement and conservation (1990–2000)

On 25 April 1990 following elections, Violetta Chamorro, head of the National Opposition Union (UNO), unseated FSLN leader Daniel Ortega, bringing an end to the revolutionary government.⁴ One of the first priorities of the new government was the end of the civil war, requiring the demobilization of both the Sandinista and contra armies. In total, there were approximately 100,000 soldiers and military officials (~22,000 contras, 72,000 Sandinistas and 5100 members of the Ministry of the Interior) who would become veterans. In addition, Chamorro was also faced with an economic recession. According to Arnson and Holiday (1991) the economy was still in hyperinflation, foreign debt was over 10 billion and unemployment was at 40%–50%.

5.6.19 Disarmament and relief aid

After negotiations and agreements were signed with contra military officials (see Stedman et al. 2002 for details) on 6 July 1990, approximately 22,000 contras were disarmed. The Chamorro Government offered several incentives in exchange for their disarmament. These included: (1) ensuring the security of disarmed generals and soldiers; (2) provision of humanitarian aid; and (3) the creation of special development poles (*polos de desarrollo*) for the resettlement of the contra military. An International Support and Verification Commission (CIAV), jointly managed by the United Nations and the Organization of American States, was established to manage the phases of assistance to the demobilized, including the distribution of food, clothing, medical assistance, household construction and farming tools and implements, and USD 50 per soldier to 111,481 ex-contra soldiers, their families and other refugees (Stedman et al. 2002).

5.6.20 Promises of land and development poles

The contra military was primarily comprised of young, undereducated males (60% with no education at all) who were from rural peasant families of Nicaragua's interior and Atlantic coasts including Matagalpa, Jinotega, Chontales, Boaco, Rio San Juan, the RAAN and the South Atlantic Autonomous Region (RAAS) (Abu-Lughod 2000). A survey of

⁴ See Smith (1996, 356) for detailed information on the role of the US Central Intelligence Agency in aiding Chamorro in electoral defeat of the Sandinistas.

the contra soldiers suggested that 83% were involved in agriculture or cattle ranching prior to joining the military and intended to return to these activities, 67% claimed they did not own land and 49% planned to resettle somewhere different from where they had previously lived (Abu-Lughod 2000). Abu-Lughod (2000) proposes that the choice to resettle elsewhere was due to feared reprisals from Sandinistas in their former communities and lack of economic opportunities due to collapse of the cotton industry. Most contra soldiers wanted access to land in exchange for disarmament; many were told they would receive 50 m² of land. However the failure to specify in any formal documentation a specific plot size, is suspected to have been a political tactic by the incoming government, as more than 1.1 million m² would have been very difficult to find and distribute (Abu-Lughod 2000). The fact that this promise was never kept caused widespread dissent amongst Contra War veterans.

The development poles are widely regarded as a failed resettlement strategy in Nicaragua as they were hastily planned and inadequately equipped. Of the USD 49 million given by the US Government for demobilization, only USD 3 million was allocated to the contra resettlement (Stedman et al. 2002). Due to inadequate funding, the contra resettlements had poor infrastructure, and were remote and far from veterans' original communities (Abu-Lughod 2000). According to Abu-Lughod (2000), "ex-contras languished in soggy camps, huddling in black plastic huts, as their sense of desperation, hopelessness, demoralization and betrayal consumed them." Key informant interviews revealed there were three development poles within the municipal boundaries of present day Siuna in the communities of La Bu, El Guayabo and Santa Juana. According to a key informant, "these [development poles] were regarded only as development poles by name, because in reality, they weren't provided with the support they needed."

5.6.21 The land market

Due to the chaos surrounding the agrarian reform titles, development poles and soldier demobilization, an estimated 25%–40% of Nicaraguan households were involved in conflicts over property rights in the 1990s (Stanfield 1995). Many of those that were not in conflict feared future conflict or validity of their titles and sold their land to incoming migrants. Titles given to agrarian reform beneficiaries or ex-contra soldiers in development poles were also sold because they became too severely indebted, the legal procedures for clearing title were too cumbersome or because neighboring landowners would not allow them to work in peace (Abu-Lughod 2000). With thousands of people seeking and selling land in the span of a few years, the government failed to manage disputes and illegal land acquisitions. Much of the land market in Nicaragua remains outside of the legal oversight of the State today. The majority of new migrants who have arrived in agricultural frontiers in the past decade have paid for their land, buying it from previous landowners or someone who has illegally claimed the land and made 'improvements' to it, simply to profit from the sale of State land.

5.6.22 Frontier advancement: North of Hormiguero and Saslaya

Hormiguero is locally known as *puerto de montaña* (mountain port), which effectively describes its role for the 30 or more Siuna *comarcas* to the north and west. It is a mountain port because it is an urban center and hub for these 30+ communities that

have formed with the progress of the agricultural frontier. The highway terminates in Hormiguero. It is thus the only connection for these communities to the rest of Nicaragua by vehicular transport. Multiple mule paths/footpaths connect remote communities located 1–10 hours from Hormiguero (Agua Sucia typically takes 2–4 hours, whilst El Inocente takes 6–8 hours).

A myriad of factors have pushed migrants north of Hormiguero and west into Saslaya. With a collapsed economy, political turmoil and civil unrest in the early 1990s, many people were driven to become self-sufficient farmers. Study participants throughout Siuna who migrated in the 1990s identified safety as a major pull factor toward settling in the region. In discussion with migrants in El Inocente, it appears that many who settled in the early 1990s were ex-contra soldiers who were tired of waiting for the government to assist with resettlement. The remote forests were chosen as a place to settle as they offered safety and protection for families and the independence to begin a new life. Moreover, land was affordable, abundant and in some cases ‘free’. Migration into the frontier at the beginning of the 1990s was a means of survival for many. FGD participants revealed that most people arrived at this time from surrounding departments including Waslala, Rio Blanco, Wiwili, Jinotega and Matagalpa.

5.6.23 Tenure, land acquisition and deforestation economics

Several forms of land/tenure acquisition and forest clearing were observed within Siuna, demonstrating a suite of agro-economic actors in Siuna’s agricultural frontier. This research revealed important differences between what has driven and what is driving deforestation when viewed from an agro-economic perspective.

The static settlers

The first settlers in Siuna owned extensive plots of land, much of which they did not clear. When the next phase of settlers arrived, many acquired subtiles from these settlers, cleared the land within their subplot and constructed a fence to mark the boundaries. Thus, for a while, deforestation mainly occurred on privately held land through the gradual clearing of larger farms. In many cases, the initial purchasing or acquisition of farmland took into account future children and grandchildren’s needs, and the families acquired as much land as they could afford. However, there were also plenty of families that were unable to purchase sufficient land to support the third generation. Discussions with these families about how they cope with insufficient land today indicated that it is common for them to adapt their livelihood strategies and uncommon to clear additional forest. Instead, common coping strategies include seeking paid labor, renting farmland or borrowing land from a family member to increase a seasons harvest.

This pattern of land subdivision is similar to what Bilsborrow et al. (2004) observed in the Peruvian Amazon, demonstrating that frontier advancement follows different models based on land acquisition behaviors. This research provides further evidence that shifting cultivation/swidden agriculture should not be presumed as the primary mode/means by which deforestation takes place. In Siuna, further deforestation is not an option in many areas due to respect for Saslaya’s boundaries, as well as that the frontier is far from many farms. Instead, alternative agro-economic strategies are being adopted to cope with insufficient and degrading land for land-poor households.

The nomadic settlers

In addition to the settlers that remain in their communities permanently, there are also those who don't permanently settle. Typically, these settlers acquire a smaller plot of land and work it for a few years farming maize and root crops. Because these farmers have made improvements to the land (clearing the land makes it easier to use for the next settler) the land value increases. As such, the farmers can sell the land for a higher price, sometimes allowing them to fetch a larger holding. This allows for incremental holding size increases. In Siuna, we suspect this model has been implemented successfully by many farmers due to the inflation of land prices between 2000–2010. Also as a result of this, land traffickers are widespread such that an illegal market has developed whereby false titles are provided for forested land. Locals and experts on the topic described that land traffickers acquire forested land within Bosawas, clear part of it, construct a fence and then seek out landless and land-poor families in other areas to move to it. Based on local accounts, at least one new family moves into the communities north and west of Hormiguero every day.

5.6.24 Re-armament and citizen gangs

The Andres Castro United Front (FUAC) was an armed citizen gang that formed in the 1990s, predominately made up of ex-Sandinista soldiers and their supporters. When the Sandinistas lost power, cooperatives were no longer provided with government benefits including credit, health care, education, agricultural tools and food rations (Staver et al. 2007), causing wide dissent toward the government. Their motivation for taking up arms was primarily the protection of the property they had obtained through the agrarian reform from the ex-contras seeking to invade the land, as well as the previous landowners whose lands had been expropriated. With the downfall of the Sandinistas, thousands of the original landowners made legal claims to recover their land or financial losses, claiming their properties were acquired under duress and under forced agreement, and that they received inadequate compensation for the land and property (Stanfield 1995). To date, Nicaragua has paid at least USD 1.2 billion in compensation for property lost (Rogers 2014).

The Northern Front

Alongside the FUAC was the rearmament of ex-contra soldiers, known as the re-contras who aligned with another group, the Revolutionary Democratic Alliance to form the Northern Front 3-80 (FN 3-80). Their primary motivations for rearmament were the failed resettlement strategy. According to Staver et al. (2007), at various times between 1992–97 the FN 3-80 took control over parts of Cua-Bocay, Waslala and Wilwili, reducing these areas to vigilante-style order and even taking control of normally State-run development, agriculture and land-titling activities.

State farm conflicts

Following their confiscation of agro-export estates, the Sandinistas had provided the peasant class with jobs on State farms. The State farms were one of the sources of land used by Chamorro when land was needed for ex-contra soldiers. This led to a loss of jobs for the farmworkers. The problem was exacerbated when the original land and business

owners wanted restitution for their property. Farmworkers who were typically neutral peasants or Sandinista supporters caused two nationwide strikes in June of 1990 that paralyzed the countries agricultural outputs via occupation of the farms (Abu-Lughod 2000). Abu-Lughod (2000) argues that the linking of land rights to a veterans program rewarded insurgent activity and marginalized nonpartisans as opposed to the civilian majority of poor peasants.

5.6.25 Bosawas' creation, conflict and lack of consultation

In Siuna, the post-war uprisings of citizen gangs was also motivated by the creation of the Bosawas Biosphere Reserve, which further contributed to land scarcity. Shortly after the contras were disarmed in November 1991, Violetta Chamorro signed Presidential Decree No. 44–91 declaring an 8000 km² area of land surrounding Saslaya National Park as a national reserve (Asamblea Nacional de la República de Nicaragua 1991). The text of the decree highlights that the underlying motivation behind Bosawas was to prohibit the advance of the agricultural frontier, urgently required for the conservation of biodiversity. According to Staver et al. (2007) and McNeely (2003) the then Minister of the Environment (Jaime Incer) felt the region would come under pressure from mining, timber companies and agricultural expansion driven especially by resettling soldiers. According to Staver et al. (2007), the incoming Chamorro Government made Bosawas part of a larger Tropical Forest Action Plan for Central America in order to garner support from the international community. Unfortunately, the demarcation of Bosawas' zones placed several communities and Sandinista cooperatives north of the Siuna–Waslala highway inside the Bosawas nuclear zone without any public consultation (i.e. Rosa Grande, Rancho Alegre, Las Quebradas, La Pimienta). Hence, many communities and farms that were well established, including Sandinista cooperatives, were placed inside the biosphere reserve. At this time, little effect of the decree on land-use activities, livelihoods, tenure and development was noted by participants; this was likely due to an absence of a clear management strategy or enforcement measures.

5.6.26 El Niño fires (1996–98)

During the dry months of 1996–98, fires raged throughout Nicaragua and elsewhere in Central America, caused by severe El Niño-induced droughts. Siuna had one of the highest densities of fire occurrences of all municipalities in the country in 1998, potentially reflective of the influx of settlers in the region (de Dixmude et al. n.d.). The community of Agua Sucia attributed 30% of their primary forest loss to these fires and explained that they worked collectively for months trying to save the forests on Saslaya mountain slopes from incineration. La Pimienta also indicated that 35% of their primary forest loss was due to these fires.

5.6.27 UNESCO Man and Biosphere Reserve

Just months after fires wiped out significant amounts of old growth forest surrounding and within Bosawas, and 6 years following Bosawas' creation by presidential decree on 28 October 1997, Bosawas received international recognition and was approved for designation as a UNESCO Man and Biosphere Reserve. The international designation brought in funding to allow for the hiring of a few forests guards (*guarda bosques*) who then informed communities that they were not allowed to hunt or cut down trees. Most people reported

1996 and 1997 as the years when they were informed about Bosawas and that there were limits to land and resource use. There was confusion over the boundaries of the reserve in communities south of Saslaya and north of the Waslala–Siuna highway. A ditch with concrete markers was created around Saslaya with funds from GIZ. There was further confusion between the boundaries of Saslaya and Bosawas, especially for communities that were told they were in the new reserve without understanding the difference between Saslaya and Bosawas (La Pimienta and Rancho Alegre).

5.6.28 Hurricane Mitch (1998)

On 28 October 1998, a Category 5 hurricane caused catastrophic flooding throughout Central America; 1600 mm of rain was recorded in Chinandega, Nicaragua (ECLAC 1999). The most severe damage occurred along the Pacific Coast especially in the cities

Table 5.8 Summary of key historical drivers/events of land-use change in Siuna (1991–2000).

Year	Drivers of land-use change	Impact on land-use change
1990–95	Failed resettlement strategy for military veterans and refugees creates thousands of impoverished ex-military land claimants Informal land market booms out of fear of loss of titles and dissatisfaction with development poles; further fueled by dissent, lack of enforcement and financial gain Bosawas is declared a reserve, enticing further dissent, lack of respect for protected area as government failed to adequately consult communities within reserve prior to creation Food and livelihood insecurity fueled the demand for land for people to feed their families	Thousands of people migrating to the agricultural frontier; land clearing for the establishment of new farms explodes
1991	Bosawas is declared a reserve by presidential decree, failure to adequately consult existing settlers and incoming migrants	No discernible impact on contributing to forest conservation or gain Entices dissent amongst existing and incoming settlers, especially landless soldiers and refugees Creation of reserve, dissent and lack of enforcement may have triggered land rush in defiance of government
1996–98	Forest fires caused by series of droughts during El Niño period	Extensive deforestation, amount requires further investigation but estimate 10%–30% of virgin forests in communities surrounding Saslaya lost due to fires Cleared land acts as a pull factor drawing in more settlers
1997	Bosawas is formally recognized as a biosphere reserve by UNESCO	Settlement in nuclear zone discouraged but not well enforced, low impact
1998	Hurricane Mitch	Damage from forest fires worsened by hurricane, increased degradation and forest loss

of Leon and Chinandega. Housing and farms located on hillsides, riverbanks and lakeshores were heavily affected (ECLAC 1999). An estimated 867,000 were left homeless, 4000 lost their lives, 287 were wounded and 1000 were reported missing (ECLAC 1999). According to Piñon (2001), Hurricane Mitch caused the most dramatic increase in poverty ever recorded in Nicaragua. Despite Mitch's intensity, it had only a modest impact in Siuna relative to other hurricanes. Hurricane Joan (1988), Beta (2005) and Felix (2007) were reported across study communities as the most significant in terms of damage to infrastructure, flooding, tree loss and erosion. Table 5.8 summarizes the aforementioned key historical drivers/events of land-use change from 1991 to 2000.

5.6.29 Hurricanes Beta and Felix (2005, 2007)

The study communities reported damage to infrastructure and farms with both hurricane Beta in 2005 and Felix in 2007. Hurricane Felix was responsible for the destruction of the bridge over the La Bu River in Rosa Grande, slowing transport between Siuna and Waslala.

5.6.30 Neo-liberalism, migration, projects and protected area management (2001–14)

Boundaries redefined and management plan (2001–2)

In 2001, 10 years following Chamorro's presidential decree, Bosawas' boundaries were redefined by Law 407: *Ley que Declara y Define la Reserva de la Biosfera Bosawas*. Prior to this, Bosawas was around 8000 km². With Law 407, the boundaries of Bosawas were expanded to approximately 20,000 km² and a buffer zone and nuclear zone were created. The difference in the latitude and longitude coordinates between the original declaration and Law 407 reveal that the territory of Saslaya National Park was extended north to the limits of the *comarca* of Sikilta (Mayagna territory), perhaps as a measure to prevent additional colonization. Unfortunately, thousands had already migrated into Saslaya over the past decade and the extension placed several communities in Siuna and San Jose de Bocay within the park. One year later, the first management plan for Bosawas was drafted. It failed to mention how to manage existing settlers within the national park or Bosawas' nuclear zone despite reports that an estimated 242,200 people resided within the reserve limits (including the buffer zone) (MARENA 2003).

Conservation induced displacement (2003)

The failure to develop a management plan for settlers inside Bosawas/Saslaya, or a suitable strategy for resettlement if evicted, led to unfortunate events in 2003. In May 2003, 117 families (750 people) were evicted from El Inocente and adjacent communities within Saslaya in accordance with the newly established boundaries of Saslaya National Park. The eviction was poorly coordinated and the actions taken appear to have resulted in several human rights violations.

During the eviction, settlers' houses, crops and animals were destroyed or confiscated. The displaced and newly homeless peasants were not provided with any land, housing, money or food provisions to assist with their resettlement and were forced out of the community and into Hormiguero. Only those with strong kinship ties were

accommodated in Hormiguero; most were forced to squat on others' land and live in rudimentary, temporary housing. According to multiple accounts and documentation of the event (including a formal letter from the community appealing to the government for support), three children died due to malnutrition and hundreds of others suffered from malnutrition and sickness due to poor housing and sanitation. Eventually, due to the humanitarian crisis, the mayor of Siuna instructed the evicted to return to their community. Nearly 100% of the surviving evicted returned to El Inocente in 2004 and have lived peacefully there without further evictions over the past decade.

Teak expansion

The private company Norteak began planting teak trees in 2010 and expanding the land area of the plantations by 400 ha per year. By the end of 2015, the area owned and planted by the plantation was expected to be 2000 ha. Norteak has been gaining land area in Siuna by purchasing and renting farmland. A few small communities surrounding the plantation have since dissolved entirely. Teak planting led to improved tree cover and wildlife habitats as land previously cultivated for pasture and basic grains was typically converted to forestry. However, further research is needed to understand where those people who sold their land migrated to and if this land purchasing was encouraging migration into Bosawas.

Migration

Hormiguero, Agua Sucia and El Inocente reported greater population increases between 2000 and 2014 than in the decade following the war, 1990–2000. Based on discussions and review of secondary household survey data, a greater number of migrants arrived in these communities in the past decade compared to the previous decade. Thus, whilst there was clear motivation for post-war migration and settlement in the 1990s, the drivers of migration over the past decade appear to be equally if not more important than those pushing and pulling migrants into the region in the 1990s. Based on household survey data collected by the Institute for Development and Democracy (IPADE)⁵ in Agua Sucia, approximately 80% of those surveyed reported that they had arrived or were born in the community after 2000.

Based on our key informant interviews and FGDs, the pull factors for migration into Siuna since 2000 have been predominately related to the accessibility to land of adequate size for family farming and the price of land. Land prices in communities without direct road access in 2000 were reported at NIO 500 per m² (USD 20/0.7 ha). The price doubled in 2005, and increased tenfold between 2005 and 2010 to NIO 10,000 per m² (USD 400/0.7 ha), reflecting the change in demand due to the growing resident population and immigration. In 2014, land prices in Siuna were between NIO 15,000–30,000 per m² (USD 600–1200/m²), although cheaper prices could be found further into the frontier. Properties with road access and improvements (i.e. housing and piped water) typically fetched a higher market value. Due to the recent inflation of land prices, migration into La Pimienta and Rancho Alegre appeared to be slowing down at the time of research. Additionally, because the communities are within Bosawas and the land is on steep terrain, they are less desirable places for settlement.

⁵ Data collected by IPADE and presented in summary report of March 2012, the title is *Comunidad Agua Sucia* but only covers data for Sector 1. Report and data made available by community leaders.

Table 5.9 Summary of key historical drivers/events of land-use change in Siuna (2001–14).

Year	Drivers of land-use change	Impact on land-use change
2000–2003	Bosawas and Saslaya boundaries redefined	Settlers evicted from Saslaya, human rights issue; low impact on land-use change as settlers return in 6 months
2005	Hurricane Beta	Damage to on-farm trees and forest edges
2005–8	Cacao cooperative union formed Chocolate factory in Rosa Grande built UNAG provides extension work in management and nutrition of cattle, development of pasture, methods of harvest and technology	Increase in tree cover on farms; farm sustainability increases farmer economic return; less likely to sell land and move into new frontier or require forest resources
2007	Hurricane Felix	Increased forest degradation
2008–13	Multiple development projects focused on improving livestock and basic grain production Ecological battalion (military division) formed improving enforcement, focus is large forest clearing captured through satellite Major projects related to cacao production facilitated ducts by Catholic Relief Services, GIZ (project MASRENACE), Bridges to Community and UNIDO	Increase in farm productivity, decrease in settlement in the agricultural frontier, increase in agroforestry Ecological battalion improves enforcement but measures are primarily reactionary; no park offices or patrol stations in rural communities or along roads into Bosawas Virgin forest thinning and clearing for cacao should be carefully monitored; cacao justified as better farming practice than alternative, however may lead to further clearing in Saslaya

There are many push factors behind migration into Siuna and Bosawas over the past decade. Landlessness continued to be a problem; many reported that people were settling in Bosawas simply because it was what was available. Soil and water degradation in other agricultural regions may have also contributed to migration in the past decade. The droughts of 2014 induced by El Niño may have triggered a new wave of land sales and acquisitions. Further research is needed on the role of family size and land subdivisions combined with land degradation in frontier migration. Table 5.9 summarizes the aforementioned key historical drivers/events of land-use change from 2001 to 2014.

5.7 Conservation challenges and management issues

5.7.1 Community-based conservation

In communities adjacent to the boundaries of Saslaya (i.e. La Pimienta, Rancho Alegre and Agua Sucia) the management of migrants who sought to settle and clear land beyond the boundaries of the park was discussed during the research. In Rancho Alegre and La Pimienta, there were older communities with settlers that have resided there since Saslaya's creation in 1971; the boundaries of Saslaya were more clearly established and community members worked to maintain them. New migrants who

tried to settle beyond the boundaries were told to leave by community leaders and by the forest guard who resides in Rancho Alegre. In Agua Sucia, boundaries were less clear and there was some debate as to whether part of the *comarca* was inside Bosawas. According to the community, they are not and according to the maps, they are. The community leaders of Agua Sucia tried to prevent settlement in the forest and worked to “save the mountain” during the forest fires of 1997–98. Boundaries need to be clearly marked and redefined in this community to prevent further settlement within Saslaya.

Community members reported the dangers they faced with regard to reporting illegal activities to authorities. During fieldwork in 2014, a community member in Parawas (inside Saslaya) reported the clearing of 80 m² of forest to the authorities and the culprit retaliated by murdering the person who made the report. The community leader of Agua Sucia has received death threats for similar actions after reporting forest clearing in Saslaya and in response, he had to move his entire family to Hormiguero where it is safer due to larger size and police presence. In some cases, communities would risk their lives by denouncing illegal activities. There is clearly a need for a permanent police or military presence beyond Hormiguero and into Bosawas. The irregular presence of the authorities only encourages further illegal activities and jeopardizes the safety of communities that are trying to conserve what remains.

5.7.2 Conservation issues

Cattle

The clearing of forest for pasture and cattle ranching is a significant problem within Bosawas; key informants from MARENA estimate there are 20,000 head of cattle within the nuclear zone of the reserve. In an effort to dissuade cattle ranching in the nuclear zone, MARENA implemented a traceability program, which would provide certification to beef for local and international markets if it was from a farm outside of the Bosawas’ nuclear zone. A major challenge to the program was cattle ranchers whose land was in the buffer zone but who rented pasture from people in the nuclear zone. There appears to be no system of tracking this.

The animals were not exclusively raised for beef; thousands of animals were produced for the dairy industry, which has grown substantially both for local consumption and international exports. The majority of farmers in the study area were or aspired to be mixed-crop dairy producers. This farming strategy is culturally preferred and has also been widely promoted by development agencies and government programs due to its benefits for livelihoods and food security. Raising a few dairy cows provides families with milk and cheese (*quajada*) – a source of micronutrients (such as calcium) that might otherwise be deficient in local diets – and helps with seasonal hunger gaps. The milk can also be sold, providing the family with an income beyond seasonal harvest earnings. In short, the traceability program will not assist small farmers with production of dairy cows in Bosawas’ nuclear zone but will help to regulate medium–large ranchers engaged in beef exports.

Land titles

Access to land titles in Siuna was first gained through Somoza agrarian reform titling and beneficiaries of the Sandinista agrarian reform titling. New land titles have been given since the 1990s for land purchased through the formal market as well as the informal

market, the latter typically being for land acquisitions within Bosawas. A major problem in the region was the lack of documentation and official registry of land titles. Some landowners held the original deed to the land if issued during Somozas time (which typically lists the name of a relative or a previous owner). In many cases, these old documents have been lost, destroyed and even confiscated. Others had Sandinista agrarian reform titles if they had managed to retain their land. Many people, possibly the majority, only held informal tenure documents that were issued by a lawyer but not officially recorded in the public registry (*escrituras*). Others had no formal documentation. Since the 1990s, land sales had been taking place based on less-than-adequate title documents. One reason for the lack of formal titling of land in the buffer zone was the high costs (of time and money) required to register land. At the time of research, people from Siuna had to travel to Puerto Cabezas, which took 8 hours by bus, and stay overnight in a hotel to have their land registered; this was too great a burden for many poor and already indebted farmers. Broegaard (2005) identifies similar problems elsewhere in Nicaragua.

Research revealed that there were numerous people within the nuclear zone of Bosawas who obtained legal titles to land within the nuclear zone of Bosawas through the Somoza and Sandinista agrarian reforms. It is not clear whether these titles are recognized or not by the current government. How the government perceives people living within the nuclear zone and their rights to use and manage land as their own private property (i.e. relative to others without legal title), is yet to be determined. Based on discussions, it seems that permits were more easily issued to Sandinista agrarian reform beneficiaries (the current government since 2008 is the FSLN). It was reported that those with Somoza agrarian reform titles had difficulty obtaining permits from MARENA. Favoritism and power dynamics between the State and peasants was troublesome and appeared to be creating dissent that could potentially result in displays of defiance (i.e. cutting trees and setting fires).

Policy of no incentives and no permissions

Through discussions with communities and government officials, it became apparent that MARENA was implementing a policy of no incentives for communities within the nuclear zone of Bosawas in Siuna. For decades, development projects related to health, sanitation, infrastructure and agriculture have occurred in communities along the Waslala–Siuna highway, including in communities within the Bosawas nuclear zone (most notably, Project Campesino a Campesino). However, in the 2 years prior to this research, MARENA had been trying to dissuade government and international projects from assisting communities inside the nuclear zone, under the assumption that if people were not being assisted, they would leave.

Cacao

MARENA's no-incentive policy included cacao agroforestry projects although many of the communities in the nuclear zone of Bosawas on the Waslala–Siuna highway had well established cooperatives and mature cacao agroforests, notably Rancho Alegre, Rosa Grande and El Balsamo. El Guayabo, a 1.5-hour drive west of Rosa Grande had the largest number of cacao producers in Siuna and the largest cooperative, as well as many farmers within the nuclear zone of Bosawas. Organizations helping with improving the

production of cacao amongst existing producers were clearly frustrated at being told they could not work with these communities. It is ironic that the current Sandinista-aligned government, through MARENA, was implementing a policy that was having a negative effect on the cooperatives they had created two decades prior to that.

Despite a lack of development assistance for communities inside Saslaya, communities reported that they have continued to improve their agricultural practices through farmer–farmer learning and exchange. Everyone travels to Hormiguero for goods, services and the sale of produce, and to learn new agricultural extension information. At least 20 farmers in El Inocente began planting cacao on their farms, in spite of a distinct lack of assistance and having been evicted 10 years prior. In discussion with them about their choices for planting cacao, their motivations were primarily financial as it provided a consistent source of income. They reported that cacao would show that they were using “good practices,” which they could use to support their land claims if ever faced with another forced eviction. These farmers had little knowledge about genetic quality, pest and disease management, shade trees or soil health relative to those in Rancho Alegre or Rosa Grande. By inhibiting extension work in the region, cacao has a high risk of failure due to low productivity and disease risks, which would result in the destruction of cacao trees and reversion of agroforests to basic grains or pasture.

Timber permits

Communities in the nuclear zone are required to apply for permits for the use of live standing or dead fallen wood on their properties. No wood is allowed to be sold outside of the community but can be used by residents for home and farm improvements. Residents of Rancho Alegre complained of waiting 6 months to receive permission for using a tree on their own property for basic home improvements. They were frustrated as they have resided in the community for decades and most landowners have planted and protected trees on their farms. One farmer commented: “I’ve planted 10 m² of agroforest and I’ve waited 6 months to use one tree to fix my kitchen.”

Fire permits

Fire is commonly used for the preparation of agricultural fields and was permitted on a small scale until 2012. In the 2014 planting season, communities were told they would not receive permits for fire and firefighting equipment was not distributed. This approach was not effective as many farmers continued to use fire due to a lack of alternatives. By not providing equipment for firefighting, forests were put at additional risk especially as it was a very dry year due to El Niño. At the time of research, those who used fire risked being fined. However, fines were not consistent and appeared to be related to power gained through kinship ties with authorities (i.e. government and police).

5.8 Food security and nutrition issues

5.8.1 Historical dietary changes

The composition of diets within the communities surrounding Saslaya Park in Siuna have evolved over the past 70 years as the landscape has transformed from a forested settlement

frontier to an agricultural mosaic. It appears that until the late 1960s, the majority of the first settlers arriving in the study region spent little time farming. Labor for food was better and time was spent hunting and working for the timber, rubber or *chicle* (gum) industries, as well as in artisan gold mining and selling animal skins. Basic foodstuffs (i.e. sugar, oil, powdered milk, sardines, basic grains, canned foods, bananas and other staples) could be purchased/traded for labor at the commissaries that were owned by resource extraction agencies. According to archives from the American Consulate (1926) a significant amount of staple foods such as corn, rice, beans and sugar were imported (via the Prinzapolka River) as early as the 1920s.

Basic grain and staples were complemented with bushmeat and fish; the abundance of both in 1940–80 was noted by all study communities. Discussions about wildlife consumption were lively, with men recalling hunting stories and women recalling participating in meal preparation and recounting their fathers' stories. The words of an elderly man in his 90s in Hormiguero who worked as a rubber tapper in the 1950s, reflect the prior role of hunting. When asked how often he consumed wild game, he replied, "That was my life," and likened his old age to the high frequency of meat consumption in earlier years. All communities reported historical consumption of wildlife; the most commonly reported terrestrial wildlife that were hunted for bushmeat are listed in Table 5.10.

At the end of the 1960s, with the collapse of the gold mine and access to large land titles in Siuna through Somozas agrarian reform, more farmers settled in the study area, typically occupying at least 50 mz. The first agriculturalists produced enough to support their families and sold/traded what they could. It was a multi-day trip

Table 5.10 Wildlife historically consumed on a regular basis in Siuna, Nicaragua.

Local name	English name	Latin name
<i>Chancho de monte</i>	White-lipped peccary	<i>Tayassu pecari</i>
<i>Cusuco</i>	Armadillo	<i>Dasypus novemcinctus</i>
<i>Danto</i>	Tapir	<i>Tapirus bairdii</i>
<i>Gallina de monte</i>	Great tinamou	<i>Tinamous major</i> and others
<i>Guardiolla</i>	Agouti	<i>Agouti paca</i>
<i>Guatuza</i>	Central American agouti	<i>Dasyprocta punctata</i>
<i>Pava</i>	Crested guan Highland guan	<i>Penelope purpurascens</i> <i>Penelopina nigra</i>
<i>Pavón</i>	Great curassow	<i>Crax rubra</i>
<i>Pisote</i>	Coati	<i>Nasua narica</i>
<i>Saino</i>	Collard peccary	<i>Tayassu tajacu</i>
<i>Venado</i>	Red brocket deer White-tailed deer	<i>Mazama americana</i> <i>Odocoileus virginianus</i>

into Siuna cabecera from the study communities until the mid 1970s when the Matagalpa–Waslala–Siuna highway was built, but the trip was usually necessary to pick up supplies. Until the 1980s, diets were still supported by bushmeat although game became harder to find as the animals were also hunted for pelts, which fetched a high price in Siuna’s markets. These pelts were typically taken down the Prinzapolka and put on ships to be sold to European and North American markets, reportedly often by Chinese merchants. Once the highway was constructed, trucks and buses passed through rural areas along the Waslala–Siuna highway. These vehicles brought new goods into the region and were essential in the operation of private pulperias (general stores/commissaries), which found it easier to improve their stock of basic foodstuffs. Rural agriculturalists produced predominately for subsistence but with the opening of the road, basic grains could be sold and transported to Siuna and Pacific markets.

During the 1980s, everything changed, and those who remained in Siuna were relocated into cooperatives where food production was carried out collectively and production was complemented by food aid packages. Hunting was reduced significantly during the war due to the danger of being killed by contra forces, but some of the braver cooperative members, typically those with military training, would go hunting on occasion. Traps were set around the cooperative. Ex-members of the Hormiguero cooperative did not identify hunger, food security and malnutrition as being problems during the war. The cooperative was very productive, even producing excess produce that was sold to the Sandinista Government.

Immediately following resettlement in the late 1980s, food and financial insecurity was a major problem for most. Farming became an immediate necessity and a way of coping with the economic downturn. Timber harvesting, hunting and fishing were also used as coping mechanisms for food insecurity. Community leaders in Rosa Grande recalled people using ichthyotoxins⁶ to fish on the La Bu and Wany rivers during this time. The 1990s were a productive time as newly cleared forested land was nutrient rich as were the fallows that had developed during the war. Increased migration brought increased forest clearing in the late 1990s. In 1997 forest clearing was exacerbated by wildfires that spread due to a prolonged drought. According to study communities, the fires marked a turning point in rural diets as wildlife and fish populations were significantly diminished (due to both overharvesting and loss of habitat). Also, the El Niño fires and turn of the millennium marked an important shift from diets being partially agrarian and partially wild to being fully agrarian.

5.8.2 Diet, food production and food access today

Basic grains and staples

The average rural diet in study communities surrounding Saslaya today consists predominately of basic grains (rice, beans and maize), staple root crops including yuca (*Manihot esculenta*), quiquisque (*Xanthosoma* sp.), malanga (*Xanthosoma* sp.) and musas. A farmer from La Pimienta gave the following description of the rural diet:

6 Chemical compounds toxic to fish.

Look, I will be honest, at the least we produce corn, which is for personal consumption; sometimes we sell the corn to sustain the family, we always have yuca and malanga as well. And, we always have rice and beans. Sometimes we are rummaging around for food. For example, today we eat tortillas, tomorrow we eat yuca, later in the day or at dinner we eat malanga. There are plantain and banana as well, and if you are too busy to cook tortillas, you put your boots on and you cut a banana and you eat.

Meat and dairy

The frequency of consumption of meat and dairy was identified as a problem. Most people in the study communities reported they did not feel they consumed adequate amounts of meat and dairy, especially the poorest. Poultry and eggs were the most commonly consumed. Based on wealth ranking exercises, in Agua Sucia, the wealthiest community members ate chicken or eggs four times a week but only consumed beef or pork once or twice a year on special occasions. Wealthier members of Rosa Grande and Hormiguero consumed beef and pork more frequently, as both communities had *pulperias* that sold frozen meat and had several medium-income cattle ranchers and middle-class residents with government jobs and private businesses (due to their location on the road).

There was a significant difference in the nutritional quality of the diets of families who owned at least one cow relative to families that had none. Regular consumption of milk can improve dietary quality and additional food can be purchased through the sale/trade of milk, especially important during seasonal hunger gaps.

Vegetables

The only vegetables produced on farms in Siuna were chayote (*Sechium edule*) and ayote (squashes), as well as *culantro* (*Eryngium foetidum*) a leafy green vegetable used for seasoning and marinating food. All of these were fairly common but were produced in small quantities, typically in patio gardens around the home. The other vegetables that were consumed included onions, tomatoes and cabbage that were typically imported from elsewhere in the country and purchased at *pulperias*. We were unable to identify any successful growers of these vegetables in Siuna. In discussions about why farmers weren't producing these crops, most claimed they had tried but the vegetables were always getting *plaques* (plant diseases and pests). Those communities without road access had less access to imported vegetables, thus dietary diversity was partially a function of distance to road. In communities off the road some informants reported that they only ate imported vegetables when they cooked meat. Rosa Grande and Hormiguero had the highest diversity of vegetables available in its *pulperias* due to their locations on the Matagalpa–Waslala–Siuna highway (Figure 5.5). Little to no produce was available in *pulperias* in remote communities. The high consumption of legumes (bean) and fruits may help to minimize the nutritional impact of low vegetable consumption. In adequate quantities, legumes and fruit can provide fiber, folic acid, vitamin C and many of the other micronutrients that would otherwise be provided by vegetables.

Fruits

A large range of fruit tree species was present in the study landscape but farm diversity and the quality of fruits produced was highly variable. Only older farms that had planted fruit trees reported on-farm access to fruit and it was not common for people to purchase

Table 5.11 Fruits grown on Siuna farms (indigenous and imported).

Local name	English (plant form)	Latin and plant form/description
<i>Sapote</i>	Sapote	Multiple species (<i>Pouteria sapota</i> most common)
<i>Annona/Guanabana</i>	Sour sop	<i>Annona muricata</i>
<i>Calala/maracuya</i>	Passion fruit	<i>Passiflora foetida</i>
<i>Castana</i>	Breadnut	<i>Artocarpus camansi</i>
<i>Cherimoya</i>	Cherimoya	<i>Annona cherimoya</i>
<i>Fruta de pan</i>	Breadfruit	<i>Artocarpus altilis</i>
<i>Granadilla</i>	Pomegranate	<i>Punica granatum</i>
<i>Guaba</i>	Ice cream bean	<i>Inga</i> spp. (4+ types)
<i>Guayaba</i>	Guava	<i>Psidium guajava</i>
<i>Jocote</i>	Jocote	<i>Spondias purpurea</i>
<i>Melocoton/Carambola</i>	Starfruit	<i>Averrhoa carambola</i>
<i>Nancite</i>		<i>Byrsonima crassifolia</i>
<i>Nispero</i>	Loquat	<i>Eriobotrya japonica</i>
<i>Noni</i>	Noni	<i>Morinda citrifolia</i>
<i>Ohoche</i>	Fig	<i>Brosimum alicastrum</i>
<i>Papaya</i>	Papaya	<i>Carica papaya</i>
<i>Pejibaye</i>	Peach palm	<i>Bactris gasipeas</i>
<i>Pera de agua</i>	Pera de malaca	<i>Syzygium malaccense</i>
<i>Pina</i>	Pineapple	<i>Ananas comosus</i>
<i>Sandilla</i>	Watermelon	<i>Citrullus lanatus</i>

fruit. There was a potential nutrition gap amongst new settlers arriving on to land without fruit trees. The most commonly consumed and planted fruits were citrus species (lime, lemon, grapefruit, orange), avocados and mangoes. The varietal diversity of these tended to be low, which is probably due to the remote location of Siuna from ports (for transport of new genetic materials), past political turmoil and the recent settlement history. Although less common, many other fruit species (Table 5.11) were found on farms, adding to the agrobiodiversity and dietary diversity of rural families.

Sapote (*Pouteria* spp.), makenque palm (*Euterpe precatoria*), peach palm (*Bactris gasipaes*), ohoche (*Brosimum alicastrum*), nancite (*Byrsonima crassifolia*) and aguacate montero (*Ocotea paulli*) are all native species to the region that have been allowed to naturally regenerate on farms. Sapote, peach palm and nancite were the most common and were sold in rural and urban markets. People reported that trips to the forest were not made specifically to collect wild fruits. The earliest settlers reported that when they first arrived and were surrounded by forest it was more common to go collecting fruit.

All fruit trees are privately owned. However, because of kinship land subdivisions, fruit is often shared amongst the larger kinship unit. People reported that children are taught at a young age not to take fruit or climb the fruit trees of their neighbors without permission. Despite this, walking through these communities we often met children who were climbing trees and eating fruit. We observed many children eating the seeds of Guaba (*Inga* spp.) between May and June on walks between Hormiguero and El Inocente (8 hours).

Seasonal food shortages

In Siuna and elsewhere in Nicaragua (see Bacon et al. 2014) between the months of June and August and sometimes into September, there is a seasonal food shortage before the harvest, requiring families to depend on stored rations of basic grains. We asked all community members about how farmers cope (in addition to storing basic grains) with financial and food supply needs during this period, particularly if there are shocks (i.e. low productivity). Several coping mechanisms were identified including: temporary employment, credit, and reliance on alternative staple crops such as plantains and tubers.

The most common coping strategy reported was to seek employment. In Siuna, it was common for people to find employment on cattle ranches clearing pasture. Fortunately, the hunger season coincided with seasonal employment on cattle ranches; the start of the heavy rains causes growth in herbaceous vegetation. Many people in the study communities found employment clearing pasture in La Bu, a community between Rosa Grande and Siuna cabecera (Figure 5.5). At the time of research, many others at Nortek teak plantation reported to employ 200–400 seasonal workers (June–August) and 250–350 fulltime employees. The Rosita gold mine also attracted many young men as one day of labor in the mine earned them twice the amount of a day of labor on farms. Others were reported to travel to the coffee regions of Matagalpa and Jinotega for coffee harvests in December–March but this supplementary income must be saved for the difficult months. Others found work in Costa Rica on agro-export farms, whilst women often found work in Siuna town as cooks or housemaids. Increasingly, people were reported to find work on cacao farms in the region but farm managers tended to prefer people who had completed some training at URACAAN in agroforestry. Credit was identified as a coping mechanism but was not as common as labor as it was difficult to acquire. Many people reported that the local *pulperias* provided loans but would only do so if a good relationship was established. If the farmer could not pay back the loan, they would have to provide labor in exchange for lack of repayment.

Diets were reported to shift dramatically between June and August to be largely composed of root crops, bananas and plantains. Informants reported that most people could purchase only a few items due to a lack of cash flow. The establishment of cacao forests with *musas* appears to have increased the amount of on-farm food available during this season. As the cacao trees mature and produce fruit (after 3 years) they provide a biweekly income source to producers that helps with the purchase of food during difficult months. Most cacao farmers interviewed reported positive dietary changes associated with cacao production, although many mentioned that they had too many bananas (*musas*).

5.9 Conclusions

Both historical events that occur over a few days or those that occur over several years can have lasting impacts on the way landscapes and societies evolve. The deforestation of Bosawas within Siuna is a result of historical events including conflict, policy change, economic conditions, dictatorships, natural disasters, droughts and wildfires. Possibly most significant are the drivers of migration. For example, this research has shown the role of multiple drivers of migration to Siuna including: the collapse of agro-exports and mineral extraction industry on human migration; forced evictions and land acquisitions of the Somoza Dynasty that created a class of land-poor peasants dependent on plantation labor; the Managua earthquake; the Sandinista agrarian reform land acquisitions; and the displacements of the Contra War. These events caused migration to Siuna from across Nicaragua as peasants sought new affordable or free land so that they could survive. The continued migration of people into the non-indigenous and indigenous areas of Bosawas has been and will continue to be the major driver of deforestation. Focusing development funds and management attention toward agricultural solutions when faced with human migration problems will not stop deforestation.

We also view deforestation in protected areas as a result of failed protected area management. Given that UNESCO Man and Biosphere Reserves are intended to be learning sites for sustainable development, we must also learn from the mistakes that are made in conservation planning. The following list summarizes how deforestation has not been prevented via the management of Bosawas:

- Creating Bosawas in 1991 by Presidential Decree was a top-down process by a new government that wasn't necessarily respected by the *campesino* class or the communities that were placed in the reserve. Bosawas already had a significant human population and deforested land the day it was created.
- The creation of Bosawas in 1990 coincided with economic recession, a land ownership crisis and thousands of people needing to be resettled.
- The lack of funds and adequate long-term plans for development poles and soldier resettlement pushed people to take matters into their own hands by settling and cultivating land.
- Failing to prepare a management plan until 2002 and failure to create any plans in consultation with existing settlers has resulted in rules that are arbitrarily enforced and not respected by community members.
- Expanding Saslaya National Park secretly using Law 407 and then evicting settlers in 2003 without a resettlement plan was a failure and a potential human rights violation.
- The logic behind the no-incentives and no-permissions policy currently being enforced assumes that if people aren't helped or their lives become difficult, they will leave. However, this may actually have the opposite effect, as communities that are not involved in conservation measures or supported by the government will not work to protect the forest that remains, both out of dissent and lack of better alternatives.

Improved management of Bosawas will only be achieved by recognizing the communities residing within it and working with them to manage the settlement of new migrants and the outmigration of existing migrants.

Acknowledgments

This research was conducted by researchers from the Faculty of Forestry at the University of British Columbia. PhD student Lisa Hansen, guided by her supervisors Dr. John Innes, Dr. Janette Bulkan and Dr. Bronwen Powell, was responsible for the fieldwork, secondary data collection, literature review and report writing. We are grateful to our University of British Columbia colleagues Dr. Sarah Gergel and Ian Eddy for their support in the spatial analysis.

We would like to thank the communities of El Carao, La Pimienta, Rosa Grande, El Inocente, Hormiguero, Las Quebradas and Rancho Alegre for allowing us to undertake this research, sharing their stories and helping us in every way that they could. We are grateful to Oscar Montalvan for his work as a field guide, mentor and community liaison; his assistance was key to making this work happen. The staff at the following organizations in Siuna provided valuable assistance and information for this research: URACAAN, Catholic Relief Services, GIZ, UNAG, Bridges to Communities, MAGFOR, MARENA and IPADE. We would like to thank the field assistants/translators Marco Zolly and Mauricio Pena and transcriptionists Karla Lara and Jennifer Temmer for their help. We would also like to thank Heirbert and the Siu family and staff of Hotel Siu for their kindness, friendship and support.

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