

NARCO CATTLE-RANCHING
IN GUATEMALA'S SIERRA DEL LACANDÓN NATIONAL PARK

by

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DEDICATION

For those working to protect the forest and preserve their way of life.

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LIST OF ABBREVIATIONS

Abbreviation	Description
CEMEC	Center for Environmental Monitoring
CIA	Central Intelligence Agency
CONAP	Council of Natural Protected Areas
DTO	Drug Trafficking Organization
LDT	Laguna del Tigre National Park
LULC	Land Use Land Cover
MALR	Market Assisted Land Reform
MBR	Maya Biosphere Reserve
MUZ	Multiple Use Zone
SDL	Sierra del Lacandón National Park
WCS	Wildlife Conservation Society

ABSTRACT

This study explores deforestation in Sierra del Lacandón National Park in Guatemala's Maya Biosphere Preserve. Central American protected areas are experiencing rapid deforestation due to cattle ranching, much of it driven by drug trafficking organizations. Through remote sensing, GIS, and a confidential report from individuals and organizations familiar with the park, this research explores spatial patterns of different drivers of deforestation.

While cattle ranching is the main driver of deforestation within Sierra del Lacandón, not all areas are experiencing cattle ranching in the same way. Data from the south-east area of the park show confirmed farming and ranching together. This research theorizes that population pressures are driving deforestation in this area.

The eastern section of the park, identified as narco-compromised, shows clear evidence of the large-scale cattle ranching operations that are associated with narco-trafficking. There are few farming locations in this zone. This is evidence of narco-cattle ranching and territory control.

The central area of the park, far from population centers, is experiencing deforestation and forest fragmentation that this research classifies as "suspected ranching." These patterns indicate land speculation, another way that drug trafficking organizations gain control of protected area lands.

I. PROBLEM STATEMENT: ILLEGAL DEFORESTATION IN CENTRAL AMERICAN PROTECTED AREAS

Despite decades of conservation efforts, deforestation and forest degradation are increasing in Central America (Hansen et al. 2013). Guatemala's Maya Biosphere Reserve (MBR) is part of this trend (Devine et al. 2020b; Devine 2018). Since the creation of the reserve in 1990, the protected area has experienced some of the world's highest deforestation rates (Davis and Sauls 2017).

While deforestation rates overall in the MBR are lower than in Guatemala as a whole, there are areas within the reserve with extremely high land conversion rates (Hodgdon et al. 2021). Between 2000 and 2015, deforestation in the Maya Biosphere Reserve was mainly concentrated in two large national parks in the reserve's west: Sierra del Lacandón and Laguna del Tigre (Devine et al. 2020a). This is consistent with a surprising deforestation pattern in Central America's protected areas. National parks, containing the region's most environmentally sensitive areas, are often most vulnerable to deforestation (Wrathall et al. 2020).

While we know that the devastating environmental impacts of deforestation are increasing in these environmentally sensitive areas, the drivers of land cover change are not always clear. Migration and population growth contribute to the advancement of the agricultural frontier into the MBR (López-Carr 2012). Commercial agriculture operations, such as oil palm, can increase deforestation by consolidating small farms and pushing subsistence farmers to cultivate new lands (Hodgdon, et al. 2021). Multiple studies suggest the largest driver of deforestation in the MBR is cattle ranching (Devine, et al. 2020a; Devine, et al. 2020b)

It is illegal to ranch cattle in the national parks of the MBR yet there exist a growing number of large-scale cattle operations within park borders. While some subsistence farmers raise livestock, large-scale cattle operations cannot be attributed to peasant farming (Devine, et al. 2020a). This type of illegal cattle ranching in the Maya Biosphere and in protected areas across Central America is often funded by organized crime. Existing research demonstrates that drug trafficking organizations (DTOs) use large cattle ranches to launder money, traffic drugs, and claim territory (McSweeney et al. 2017; Devine, et al. 2020a; Devine, et al. 2020b). As such, analysis of illegal cattle ranching can serve as a proxy indicator of drug trafficking activity (Devine, et al. 2020a).

A challenge to measuring this driver of deforestation is that drug trafficking organizations are not the only people engaging in illegal land use in the reserve. The MBR is also home to families and communities practicing subsistence agriculture, many of whom are farming illegally according to conservation law (Grandia 2012). Many of these families are Indigenous and others were displaced by Guatemala's decades-long civil war (Grandia 2012). Although there are more small farmers than narco-traffickers, the rapid, large-scale deforestation associated with drug trafficking activities has disproportionate environmental impact relative to small, patchy forest loss areas attributed to subsistence farming (Sesnie et al. 2017; Suter and López-Carr 2018). These landless migrants are often the focus of enforcement of deforestation regulations within the national parks, in part because protected area managers are unable or unwilling to address larger and more powerful drug trafficking organizations ((Suter and López-Carr 2018; Wrathall, et al. 2020).

This study aims to quantify and differentiate deforestation from peasant farming and large-scale, narco-funded cattle operations in Guatemala's Sierra del Lacandón National Park. Because the drug trade is illicit and depends on concealment, it can be difficult to accurately map drug transit routes and measure their impacts on ecosystems and protected areas (Tellman et al. 2020). By using remote sensing techniques, classifying land use behaviors, digitizing known narco-compromised territories, and analyzing these data in GIS, this directed research project examines different land uses as one way to spatially explore the drivers of deforestation in Sierra del Lacandón National Park.

This study contributes to analysis of deforestation drivers in Central American protected areas and a growing body of research connecting the drug trade with environmental losses in the region by exploring how cocaine trafficking is transforming physical landscapes. In doing so, it contributes to existing public and academic debates regarding the drivers of deforestation in Central American protected areas and the role of organized crime in global environmental change and degradation.

II. BACKGROUND: MAYA BIOSPHERE CREATION AND GOVERNANCE

The Maya Biosphere Reserve (MBR) is rich in biological and cultural significance. It is part of the largest broadleaf forest in Mesoamerica, provides habitat for countless species of flora and fauna, and houses remains of ancient Maya civilization (Hodgdon, et al. 2021). The reserve is more than a cultural heritage site and biological preserve. It is also home to 180,000 people who live within a complicated structure of conservation governance (Hodgdon, et al. 2021). This section provides historical context regarding the Guatemalan civil war, land distribution, and the creation of the Maya Biosphere Reserve with its complex geographies of land tenure and conservation.

Formation of the Maya Biosphere Reserve

In Guatemala land ownership is highly unequal. Guatemala has the least equitable land tenure system in Latin America (Gauster and Isakson 2007). This inequality is fundamental to understanding the challenges that arose with the creation of national parks within the MBR, including Sierra del Lacandón (Devine 2018). The Maya Biosphere Reserve was formed in 1990 during Guatemala's eleven-year peace process following three decades of civil war. During the civil war, the Petén, the department housing the MBR, served as an "escape-valve" for land poor or landless Guatemalans fleeing violence (Suter and López-Carr 2018).

The resulting colonization of the Petén from the 1960s to the present reflects previous failed efforts at land redistribution and reform in the south of the country. In 1950, when Jacobo Arbenz was elected president in Guatemala, just two percent of the population controlled 72% of arable land and only 12% of this land was under cultivation

(Trefzger 2002). For a predominantly rural society based on subsistence farming, this concentration of farmland kept most Guatemalans impoverished. Two years into his presidency, Arbenz instituted land reform that aimed to redistribute lands from holdings greater than 85 hectares and compensate landowners at the stated tax value of the property (Trefzger 2002). This threatened large landholders and multinational corporations who had undervalued their land for tax purposes and now stood to lose land, power, and influence (Gould 2014). In response, large corporations and Guatemalan elites supported a coup planned and executed by the United States Central Intelligence Agency (CIA) that reversed the land reform and led to decades-long civil war (Schlesinger and Kinzer 2005).

During the civil war, the Guatemalan government opened the Petén for legal settlement. At the time, population distribution in the country was extremely uneven. In the densely populated highlands, there existed significant land shortages while other areas, like the Petén, remained sparsely populated by comparison (Pearson 1963). In the Petén, new migrants often displaced small farmers, including Indigenous Q'eqchi families who had been on the land for generations (Gould 2014). During the 1960s and 1970s, the Guatemalan government built new roads to the Petén, which resulted in increased migration and rapid population growth from 21,000 inhabitants in 1960 to an estimated 200,000 in the early 1980s (Schwartz 1987). While this program had the potential to alleviate land inequity, the new titling regulations favored large ranchers over small farmers. The legal land titling process was never able, or perhaps not designed, to keep up with demand and left many peasant farmers unable to secure land (Gauster and Isakson 2007).

Legal migration into and within the Petén changed with the formation of the MBR in 1990. The MBR was created with the stated intention of preserving forested land and cultural resources (Nations 2006). The strict conservation approach, which prioritizes conservation goals over the needs of those living on the land, exacerbated tensions between government and residents already living in these area (Devine 2018; Cronon 1996). This further dispossessed Guatemalans, many of them Indigenous, of land rights and imposed conservation priorities out of step with the needs of people currently there (Wrathall, et al. 2020; Ybarra 2018).

The 1996 Peace Accords also failed to address agrarian inequality (Gauster and Isakson 2007). In lieu of state-led redistribution, the Guatemalan government implemented a World Bank sponsored program of market-assisted land reform (MARL). Rather than alleviating land tenure inequality, MARL instead led to a reconcentration of land holdings (Gauster and Isakson 2007; Grandia 2012).

The Guatemalan government reneged on its promise of a \$40 million land purchase fund for peasant farmers and the World Bank loans for regulation and market assistance left the limited beneficiaries indebted (Gauster and Isakson 2007). The program resulted in a land grab that, far from benefiting landless or land-poor peasants, instead helped cattle ranchers, oil palm plantations, and, subsequently, the drug trafficking organizations who use these industries for territory control (Gould 2014).

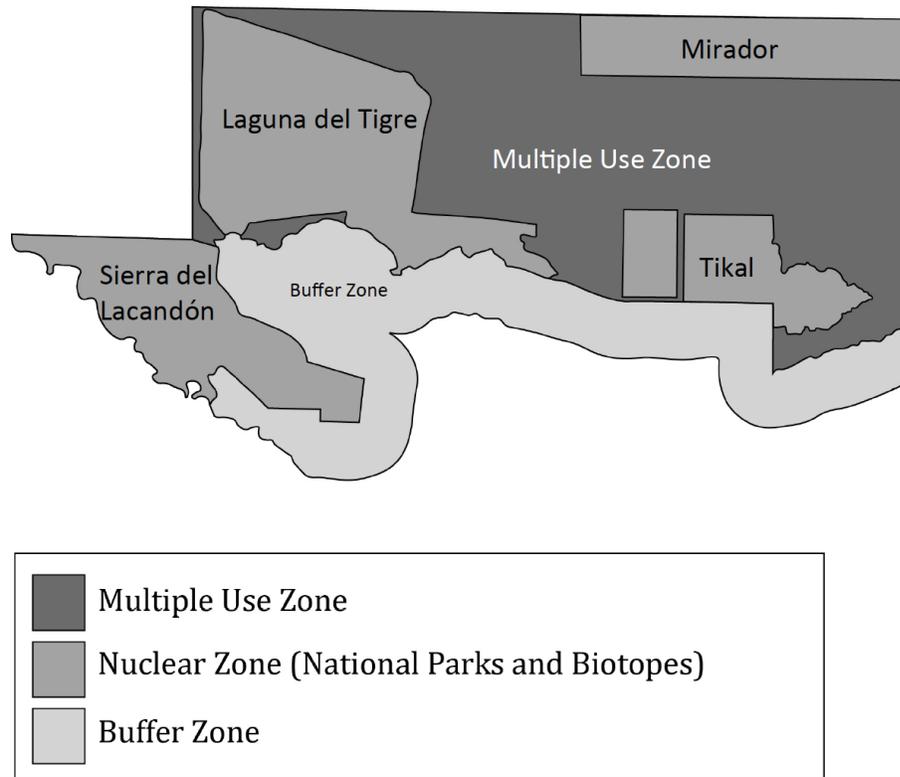
The failure of MALR pushed many landless and land poor people into national parks like Sierra del Lacandón because they had no place else to go. Because the underlying causes of land inequality have never been adequately addressed, migration

and colonization of the Maya Biosphere Reserve, including Sierra del Lacandón National Park, continues (Hodgdon, et al. 2021; Suter and López-Carr 2018).

Governance Structure of the Maya Biosphere Reserve

The Maya Biosphere Reserve is composed of areas with different regulations and governance structures. There are three main designations: a nuclear zone of national parks and preserves, a multiple-use zone where forest concessions operate with limited extraction rights, and a 15 km-wide buffer zone in the south of the preserve created with the intention of reducing pressure on more sensitive land areas (see Figure 1).

Figure 1: Guatemala’s Maya Biosphere Reserve



Source: Devine, et al. 2020a

The most ecologically and culturally sensitive areas were placed under the strictest conservation measures (Devine, et al. 2020b). These nuclear zones form over one-third of the total land of the MBR. The areas are not contiguous. Instead, they are twelve distinct locations situated around the outer edges of the park. The nuclear zones include six national parks, four biotopes, one cultural monument and one cultural reserve. While some exceptions were made to allow for continued presence of established communities at the time of the 1990 formation, MBR regulations prohibit further human settlement, land sales, and cattle ranching in the nuclear zones (Hodgdon, et al. 2021). Sierra del Lacandón is one of the twelve nuclear areas of the MBR. Located in the western part of the reserve, it is a hilly area of primary forest jointly managed by the non-governmental organization Fundación de los Defensores de la Naturaleza (Foundation for the Defense of Nature) and the Guatemalan government's Council of National Protected Areas (CONAP) (Suter and López-Carr 2018). These two organizations work with legally residing inhabitants of the park (those who were present when the park was formed) to negotiate continued land tenure as the communities continue to grow (Suter and López-Carr 2018).

Guatemalan law allows limited extraction in the multiple-use zone by approved groups. During the establishment of the MBR, peasants organized and secured forest concessions and communal-based land rights in the eastern and central areas of the reserve (Devine 2018). This multiple-use zone covers 40% of the reserve and allows sustainable harvest of forest products by 12 communities and two industrial forest concessions. Like the national park areas, the multiple-use zone prohibits cattle ranching (Hodgdon, et al. 2021).

The final land classification, the buffer zone, allows for human settlement, extraction of forest resources, farming, cattle ranching, private land tenure, and land sales. The intention was that the buffer zone would lessen the environmental impact on more sensitive areas of the reserve.

With this governance structure, one might expect the areas with the strictest protection, like Sierra del Lacandón National Park, to experience the least forest loss. However, the national parks in the western area of the reserve are experiencing deforestation at some of the highest levels in the world (Clark, Aide, and Riner 2012; Hansen, et al. 2013).

III. LITERATURE REVIEW: ILLICIT DRIVERS OF DEFORESTATION IN CENTRAL AMERICA

This research is part of a larger study exploring areas of the Maya Biosphere Reserve experiencing the most rapid levels of deforestation (Devine, et al. 2020a). While it is clear that areas of the MBR are experiencing rapid forest loss, what is not clear is the relative contribution of farming, cattle ranching, and forest loss related to land speculation for narco activities. This research contributes to two bodies of literature: drivers of deforestation in Guatemala's Maya Biosphere Reserve and drug trafficking's environmental impacts.

Drivers of Deforestation in Guatemala's Maya Biosphere Reserve

Deforestation debates in the Maya Biosphere Reserve center on two themes: conservation governance models' impacts on forest cover and the relative impact of different land uses as drivers of deforestation. Deforestation in the MBR is highly uneven both within and between the three different types of conservation zones (nuclear, multiple-use, and buffer) with their corresponding land use restrictions and governance systems. Comparing rates of deforestation between the three land use classifications is challenging because parcels of land have fared differently.

Overall, the multiple-use zone that is home to community-forest concessions has been more effective at curbing deforestation than both the buffer zone (with no land use restrictions) and the Sierra del Lacandón and Laguna del Tigre National Parks (with the strictest land use restrictions) in the western half of the reserve (Blackman 2015; Davis and Sauls 2017). Studies indicate that the community-based conservation groups have

better protected land from deforestation pressures (Davis and Monterroso 2014; Nelson; and Chomitz 2011; Taylor 2010; Taylor 2012) and that deforestation is close to zero percent in active community forest concessions (Davis and Sauls 2017). In part, this is because within the community forest concessions in the multiple-use zone, community members are incentivized to protect and regulate the communal use of forest resources (López-Carr 2012; Lopez-Carr and Burgdorfer 2013).

This incentivized communal protection is not present in the nuclear zones where protected land can be perceived as both available and idle (Lopez-Carr and Burgdorfer 2013). Deforestation pressures and government assistance vary greatly in the twelve national parks and biotopes classified as nuclear zones. The Guatemalan government and the United Nations Educational, Scientific, and Cultural Organization (UNESCO) have invested heavily in the protection of Tikal, a UNESCO Natural and Cultural World Heritage Site. In contrast, Sierra del Lacandón and Laguna del Tigre national parks are underfunded, understaffed, and conservation laws are often unenforced (Hodgdon, et al. 2021; Wrathall, et al. 2020).

While the bulk of migration in Central America has been rural to urban since the middle of the last century, rural-to-rural frontier migration continues to drive deforestation (Lopez-Carr and Burgdorfer 2013). Migrants to the Maya Biosphere Reserve cited lack of land or degraded land as their primary reason for migration (López-Carr 2012). Small-scale farming in protected areas by landpoor or landless migrants leads to forest fragmentation (Lopez-Carr and Burgdorfer 2013). This fragmentation can lead to farm expansion and then land consolidation by larger farming operations, again displacing those who farm the land but do not own the land. These migrant farmers

without land tenure are then forced to move to a new frontier. In this way, a single family can clear several areas of land over their lifetime (López-Carr 2012).

Carr argues that frontier migration “has an immediate, enduring, dynamic, and disproportionately large impact on global deforestation, particularly within and adjacent to protected areas” (Lopez-Carr and Burgdorfer 2013). Carr and Bergdorfer (2013) believe that this driver may be under-represented by some remote sensing methods that can conceal the relatively small-scale deforestation of migrant farming.

Devine et al. 2020, has shown cattle ranching to have a much larger impact. In this article, we investigated drivers of deforestation in the three areas most impacted in the MBR: Laguna del Tigre National Park, Sierra del Lacandón National Park, and an area surrounding a road in the multiple-use zone. This research clearly demonstrated that illegal cattle ranching, and not subsistence farming is the main driver of deforestation in each of the three study areas (Devine, et al. 2020a).

However, not all cattle ranching is the same. Sierra del Lacandón (SDL) has been illegally colonized by a diversity of actors with different levels of socio-economic status. While some small farmers have one or two head of cattle, there are also large illegal cattle ranchers in SDL with ties to organized crime (Devine, et al. 2020a). In this context, cattle ranching can be used for money laundering and territory control (McSweeney, et al. 2017). Land speculators illegally clear and then sell “improved” or deforested lands to drug trafficking organizations (DTOs) interested in claiming territory, building airstrips and smuggling drugs (McSweeney, et al. 2017). My research colleagues and I at Texas State have identified land speculation as a driver of deforestation within the MBR (Devine, et al. 2020a).

Narco-Deforestation and Degradation in Central America

Sierra del Lacandón and the Maya Biosphere Reserve are not the only protected areas in Central America experiencing rapid deforestation. Similar patterns of environmental degradation and deforestation have been tied to drug trafficking activities across the region (Sesnie, et al. 2017; Tellman, et al. 2020). To understand why drug traffickers are ranching in Central American national parks, it is critical to analyze dynamics unfolding outside of protected areas.

The large-scale narco-deforestation in Central American protected areas is the result of the United States drug policy of military interdiction (Devine, et al. 2020b; UNODC 2012). In the mid-2000s, these policies brought the drug war to the MBR when the United States government and the Mexican government under the leadership of the National Action Party (2000-2012) increased drug enforcement in Mexico (UNODC 2012). This did not stop the flow of drugs. Instead, traffickers changed routes and redirected their product through Central America (UNODC 2012; McSweeney et al. 2014). This change in trafficking routes is known as the balloon effect (Friesendorf 2005). Enforcement in one area (squeezing the balloon) does not eliminate trafficking, but rather pushes drug transit to other locations (Friesendorf 2005; Magliocca et al. 2019). Instead of stopping the flow of drugs, interdiction has expanded the geographic area of drug transit (USGAO 2017; McSweeney et al. 2018). As trafficking routes change, so do narco land grabs, generating a positive feedback loop producing conditions for additional drug trafficking (Magliocca, et al. 2019). The increase in areas of drug transit over the past twenty years, from two million square miles to seven million square

miles has created another balloon effect, that of environmental loss (McSweeney, et al. 2018; USGAO 2017).

Narco-traffickers seek to operate in remote areas with weak governance and contested land rights (Magliocca, et al. 2019; Devine 2018). For this reason, many protected areas in Central America are disproportionately impacted by ecological losses related to cocaine transit (Wrathall, et al. 2020). The result is that the national parks in the western section of the Maya Biosphere Reserve have experienced deforestation at some of the highest rates in the world (Hansen, et al. 2013).

Central American forest loss is a cause for concern and the specific type of forest loss associated with narco trafficking is especially problematic. Drug traffickers utilize large landholdings in remote areas to assist with transit and to launder cash, often through cattle ranching or African oil palm cultivation (McSweeney, et al. 2017). Forest loss connected with cocaine trafficking activities is markedly different from landscape change attributed to migration and subsistence farming. It involves rapid clearing of large parcels of land in remote locations, often protected areas (Sesnie, et al. 2017). To use the Rio Plátano Biosphere Reserve in La Mosquitia, Honduras, as an example, after 2005 there was a “significant departure” from clearing of land for small, individual farmers to an anomalous deforestation pattern that includes patches of land greater than 100 hectares (Sesnie, et al. 2017). It can be difficult to parse apart causes and accurately measure the ecological impacts of narco-trafficking (Tellman, et al. 2020; Sesnie, et al. 2017). Sesnie et al. (2017) attributed 15-30% of Central American forest loss to drug transit but stated those results likely “greatly underestimated” deforestation resulting from narco-trafficking activities (p. 14).

This project adds to the literature of deforestation in protected areas in Central America by separating and measuring drivers of deforestation (farming, ranching, and land speculation) and exploring spatial patterns within the frontiers of deforestation in Sierra del Lacandón National Park. Additionally, this research contributes to the literature of narco-deforestation by separating cattle ranching from other agricultural activities and exploring methodology to measure narco-land speculation, even where cattle are not present.

IV. RESEARCH METHODS: MEASURING THE ENVIRONMENTAL IMPACT OF CLANDESTINE ACTIVITIES

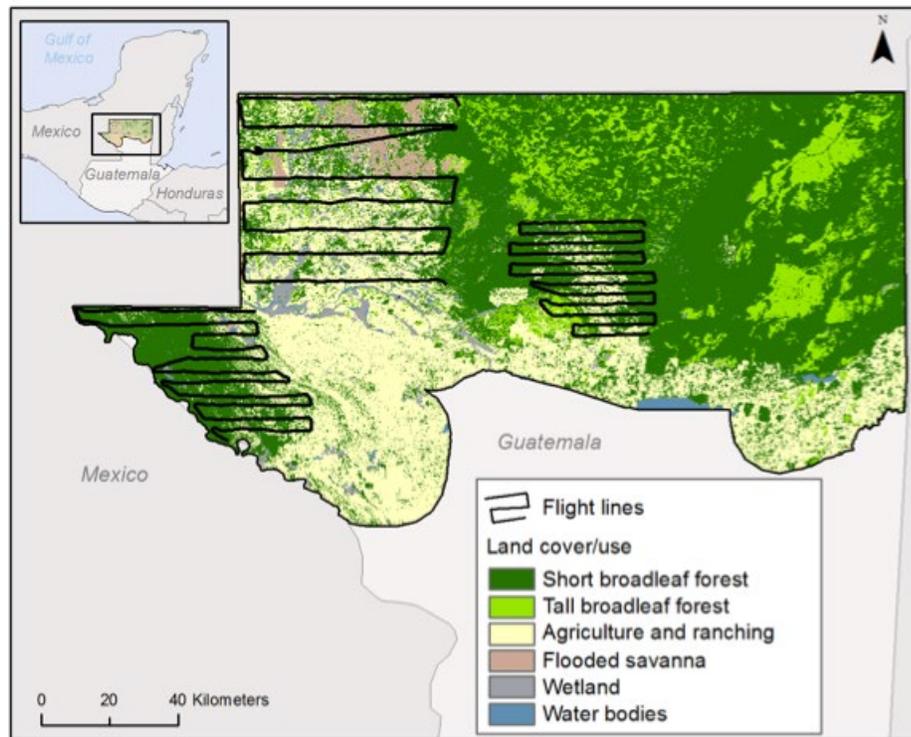
Deforestation is illegal within SDL National Park. Measuring environmental impact and determining causation can be challenging because illicit actors attempt to conceal their actions. This project draws on two primary data sets. The first is a remotely sensed set of images and a corresponding quantitative database analyzing the presence of cattle in the three sample areas of the MBR with high rates of deforestation: Sierra del Lacandón National Park, Laguna del Tigre National Park, and an area surrounding a road to the village of Carmelita in the multiple-use zone. The second data set is an internal memo qualitatively detailing the location and nature of drug trafficking activity and its environmental impacts in SDL.

Quantitative Data Source: Cattle Database

The Wildlife Conservation Society (WCS) and the Guatemalan Center for Environmental Monitoring (CEMEC) have monitored cattle presence in four areas of the MBR by taking aerial photographs following similar flight lines in the years of 2011, 2012, 2013, and 2015.

In each of the four different years of study, they took over 4,500 individual photographs. The research team then visually analyzed the series of photographs and identified cattle presence in the photograph if any of the following variables were identified: pasture, fences, corrals, watering holes, or cattle. The visual analysis did not include identification of farming activities, land speculation, or any links to suspected drug trafficking organizations.

Figure 2: Areas of Study including Flight Lines



Source: WCS/CEMEC

Qualitative Data Source: Narcotrafficking Report

Our research team was able to access a report identifying narco-controlled territories and environmental impacts within Sierra del Lacandón. This “internal memo” was produced by an organization with first-hand knowledge of issues and given to our team with the requirement that their confidentiality be protected. While aerial photographs and GIS help to measure and map deforestation, information from those on the ground is key to understanding how and why deforestation is occurring.

The report locates known narco-compromised territories within the national park and describes ways that illicit actors gain control of territory: deforestation and territory

control from the growth of legal and illegal communities; illegal cattle ranching for both commercial use and land control purposes; the building of illegal roads and infrastructure to control territory and fragment park property; and illegal logging for the extraction of mahogany and cedar.

Data Analysis: Remote Sensing and GIS Interpretation of Ranching, Farming, and Land Speculation

The WCS/CEMEC photos had already been analyzed to determine cattle ranching presence. However, the data set does not identify farming or land speculation activities. Our research team examined all 4,582 photographs from the 2015 data set to provide this distinction.

We looked at each image to identify “confirmed” and “suspected” farming and ranching. The classifications we devised for land uses include: 1) confirmed farming, 2) suspected farming, 3) confirmed cattle ranching, and 4) suspected cattle ranching. Some of the photographs included more than one land use type in the same image and these were classified as 5) confirmed farming and confirmed ranching, 6) confirmed farming and suspected ranching, 7) suspected farming and confirmed ranching, or 8) suspected farming and suspected ranching. We also noted if there was no evidence of human driven land change (see Figure 3).

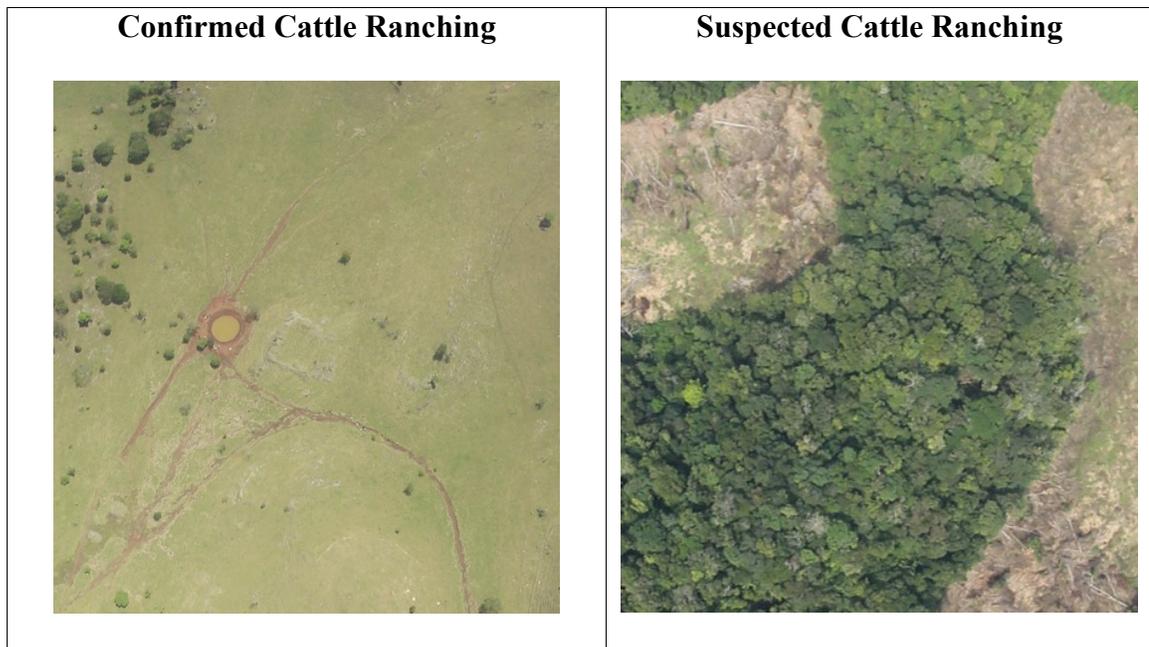
Figure 3: No Evidence of Human-Driven Land Change



Source: WCS/CEMEC

We classified an image as “confirmed cattle ranching” if both our team and the WCS/CEMEC identified cattle ranching using WCS/CEMEC’s method of identifying pasture, fences, corrals, watering holes, or cattle. If WCS/CEMEC did not confirm cattle ranching, but the deforested land looked as if it was cleared for cattle ranching (large land clearings, straight lines, tractor marks), we classified the image as “suspected cattle ranching” (see figure 4).

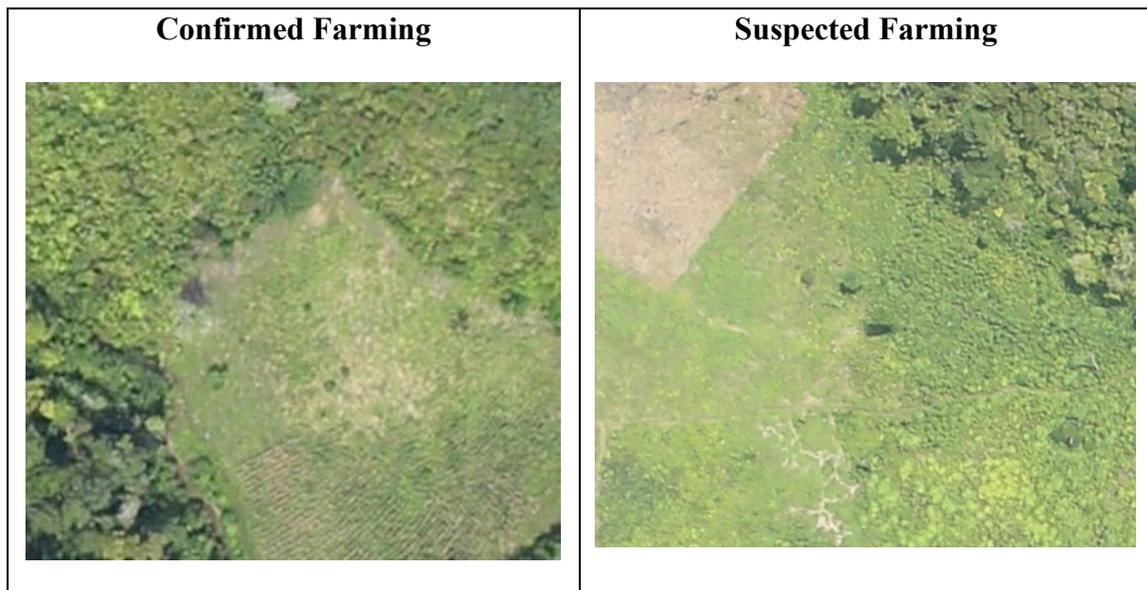
Figure 4: Cattle Ranching



Source: WCS/CEMEC

Smaller clearings (10 hectares or less), or clearings that followed terrain lines (not straight lines) were classified as “farming.” Our team classified an image as “confirmed farming” if evidence of row crops was present in these smaller, irregular clearings and “suspected farming” if the clearing was small (10 hectares or less), was near other confirmed or suspected farming activity, and/or had an irregular shape with undulating lines. The difference between suspected and confirmed farming is that confirmed farming locations have presence of crops or tilled land. We chose 10 hectares or less as the threshold to distinguish subsistence versus commercial, large scale land use change. In our efforts to not overestimate the role of narco-capitalized ranching in land use change, we chose a large clearing size that the literature identifies as well beyond the scale of subsistence or semi-subsistence production (Schwartz and Corzo M 2015).

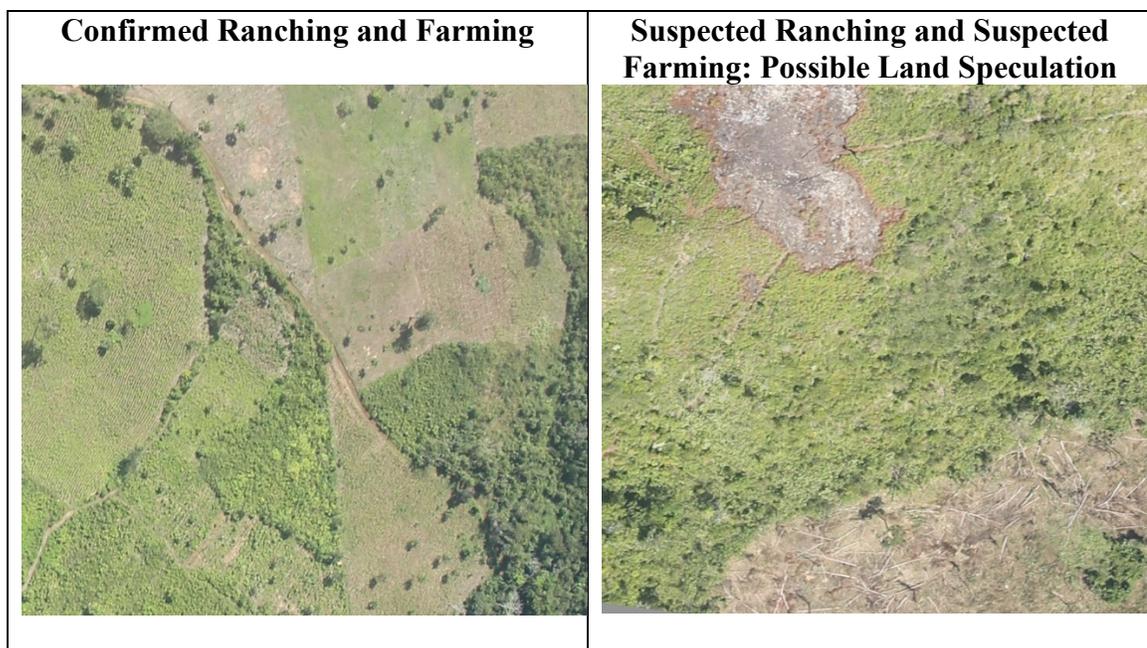
Figure 5: Farming



Source: WCS/CEMEC

Some of the images showed evidence of both ranching and farming. In these cases, we allowed each image to be classified as more than a single land use. All of the photographs classified as “suspected cattle ranching” or “suspected farming” showed clear evidence of human driven land change but no direct evidence of either farming or ranching. Each of the images classified as suspected ranching or suspected farming were collectively interpreted a second time as a team.

Figure 6: Mixed Land Use



Source: WCS/CEMEC

Within GIS, I added the coded information to the geolocated images in the database and analyzed the information to explore spatial patterns for these different drivers of deforestation.

Data Analysis: Content Analysis and Digitization of the Internal Memo

The internal memo identifies four locations within Sierra del Lacandón park that are described as “ungovernable,” meaning areas operating outside of park administration

control. Within these four geographic areas of concern are five separate human settlements that are either expanding territory illegally or were built in areas where no human settlement is allowed.

Using the information within the internal memo, I digitized the areas and added this layer to the GIS database of geolocated images from WCS/CEMEC. This allowed a spatial analysis of the different drivers of deforestation identified in the first dataset (confirmed and suspected farming and ranching) within the context of the known criminally compromised areas.

The document lists specific ways that illicit actors have gained control of territory as well as the means that they use to maintain control. We categorized the types of narco-activity described and coded for activity and magnitude of environmental impact. This on-the-ground account of deforestation offers a more nuanced understanding of the areas of suspected farming and ranching identified in the first dataset. While drivers of land use change may not always be clear from aerial photographs, the addition of first-hand reporting offers more information to clarify deforestation drivers.

V. ANALYSIS: NARCO-CATTLE RANCHING AND LAND SPECULATION IN SIERRA DEL LACANDÓN

This section presents the results of my analysis of the drivers of illicit deforestation in Sierra del Lacandón (SDL) National Park in Guatemala's Maya Biosphere (MBR). I use remote sensing analysis, spatial statistics, GIS, and qualitative content analysis to measure different drivers of deforestation: ranching, farming, and narco-capitalized deforestation, also known as “narco-deforestation” (McSweeney, et al. 2018).

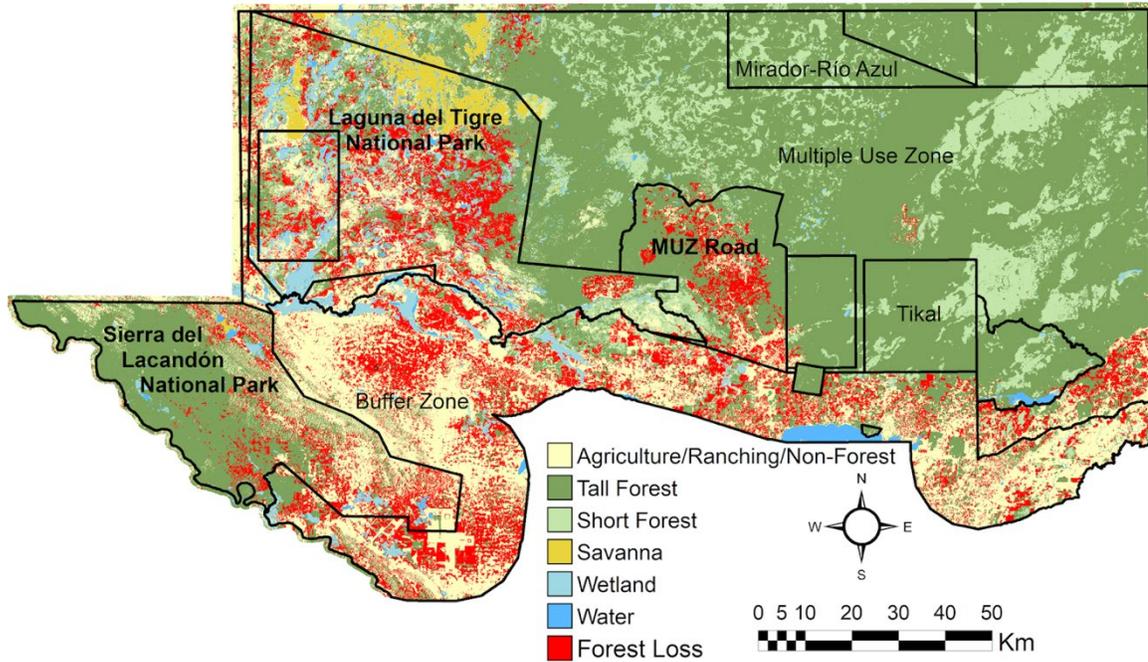
I begin by placing this research in context by drawing on my larger team’s analysis of land use land cover change in the MBR and our research on three areas of illicit deforestation: Sierra del Lacandón National Park, Laguna del Tigre National Park, and the area surrounding the main road running south to north to the village of Carmelita in the multiple-use zone of the MBR. In this past research, we determined the overall percentage of deforestation in each of the three study areas by measuring the percentage change from short and broadleaf forest to agricultural use (both ranching and farming). In the following sections, I explore different drivers of deforestation in Sierra del Lacandón National Park: ranching, farming, and narco-deforestation. For ranching and farming, I analyzed aerial photographs to determine the type of land use driving deforestation and coded each photo with evidence of human-driven land change as confirmed or suspected farming, confirmed or suspected ranching, mixed land use, or indeterminable land use. I explored spatial patterns in these different drivers of deforestation. To explore narco-deforestation, I utilized on-the-ground accounts of

narco-compromised areas as described by individuals with intimate knowledge of the park and digitized these known narco-compromised areas.

Deforestation in the Maya Biosphere Reserve: Changing Land Cover as a Proxy for Deforestation

Our research team has previously measured deforestation in three sample areas on the MBR (Devine, et al. 2020a). Land use and land cover change (LULC) in the Maya Biosphere Reserve shows deforestation concentrated in four areas: Sierra del Lacandón National Park (SDL), Laguna del Tigre National Park (LDT), the area surrounding the Multiple Use Zone (MUZ) Road, and the buffer zone area. Past research explored three study areas (SDL, LDT, and MUZ road) that experienced forest loss and increased agricultural land use over a fifteen-year study period of 2000-2015 (Devine, et al. 2020a). In Sierra del Lacandón, 15% of short leaf and broadleaf forest changed to agriculture/ranching. In Laguna del Tigre and the multiple-use zone road, the percentages were an astounding 30% and 23% respectively (Devine, et al. 2020a).

Figure 7: Land Use and Land Cover Change 2000-2015



Source: Devine et al., 2020a

While this previous research calculated the percentage of cattle ranching activity on deforested lands, we did not analyze spatial patterns of deforestation or nuances between suspected and confirmed farming and ranching activities. These patterns may offer insight into the process of deforestation and forest fragmentation. Additionally, the deforestation in Sierra del Lacandón differed from the other two study areas because it had the highest number of images classified as suspected (not confirmed) farming and ranching. These suspected land uses raised several questions that warranted a closer look. The following sections explore in greater detail the drivers of deforestation in Sierra del Lacandón National Park.

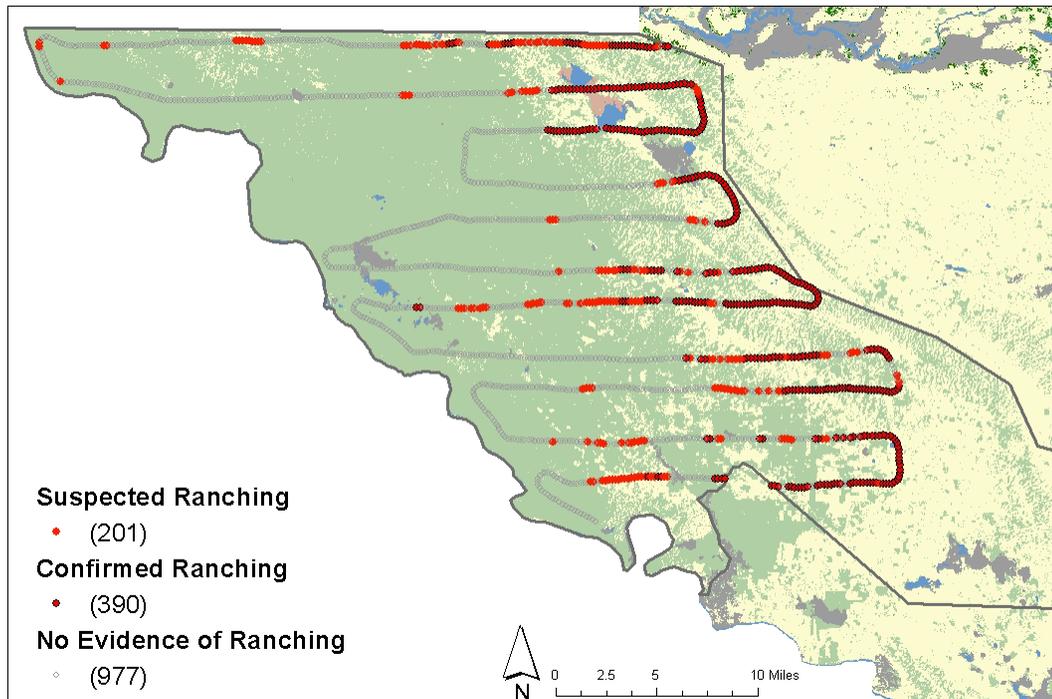
Drivers of Deforestation in Sierra del Lacandón: Cattle Ranching, Farming, and Land Speculation

This research used coded data from aerial photographs examined by CONAP and our team of researchers (Devine, et al. 2020a). The analysis sometimes indicated more than one type of land use for each data point. To explore geographic patterns, I allowed each data point to represent all observed land uses. Of the 1,568 photographs in the dataset, 606, or 38.6%, showed evidence of human-driven land change activities. Within this subset of 606 photos, an astounding 97.5% (591 of 606) showed evidence of either confirmed or suspected cattle ranching. This project's analysis clearly shows that cattle ranching is the main cause of deforestation in Sierra de Lacandón National Park.

Confirmed and Suspected Cattle Ranching

This section presents the results of analyzing illegal cattle ranching as a driver of deforestation by separating suspected and confirmed cattle ranching activities. Of the 606 images with human driven land change, 390 data points (64.3%) confirmed the presence of cattle ranching and 201 images out of 606 (33.1%) showed suspected cattle ranching. With few outliers, the confirmed cattle ranching activities were on the northern edge of the park and in the eastern section (see Figure 8). The northern edge of the park borders Mexico and the eastern edge of the park borders the buffer zone where community settlements, farming, and ranching are allowed.

Figure 8: Confirmed and Suspected Cattle Ranching in SDL



Source: Author

The areas of suspected cattle ranching were located along the northern park border with Mexico, interspersed with confirmed ranching locations in the east, and, surprisingly, in the central area of the park. These locations are of interest because they may show the frontier of deforestation and help us to understand where and how deforestation is spreading. As shown in Figure 7, the LULC analysis of the central area of the park showed relatively limited deforestation. However, aerial photographs indicate human-influenced land use change.

The locations of confirmed and suspected ranching in Sierra del Lacandón National Park show increasing deforestation in areas already impacted by farming and ranching as well as westward expansion of deforestation toward the interior of the park. The spatial analysis shows distinct groupings or spatial patterns: the south-east area of the park, the northern border, the eastern edge of the park, and the park's interior.

The concentration of confirmed ranching locations in the south-east area of the park may indicate population pressures and movement into the park from nearby park borders where ranching is allowed. These areas, the most deforested in the park, are also locations of human settlement.

The eastern edge of the park has a high concentration of confirmed ranching with some indication of suspected ranching. This area also borders human settlement on the buffer zone.

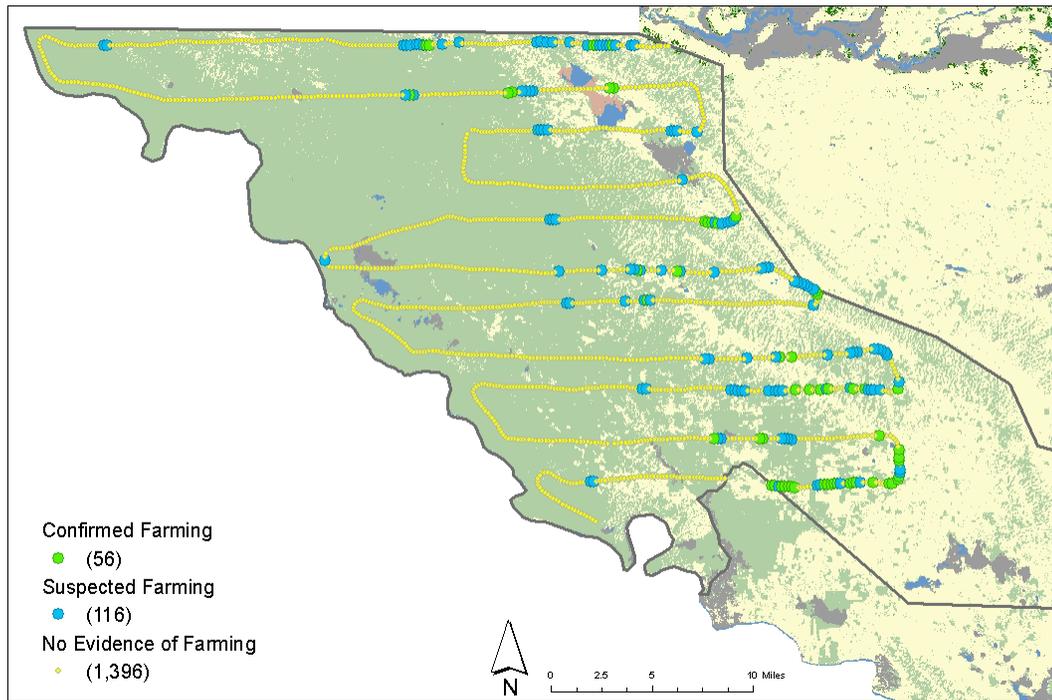
The concentration of confirmed and suspected ranching areas located along the northern edge of the park, the border with Mexico, tells a different story. We know that border areas are often used for illicit passage and it is possible that the deforestation in these areas could indicate territory control (Devine, et al. 2020b).

The locations of suspected ranching in the central area of the park, far from areas of confirmed cattle ranching activity, may indicate a frontier of deforestation driven by territory control through land speculation and cattle ranching. These locations show a westward movement of deforestation and forest fragmentation that is driven by ranching.

Confirmed and Suspected Farming

Cattle ranching is not the only cause of deforestation in Sierra del Lacandón National Park. My research indicates that illegal farming is also occurring, although at a much smaller scale. Of the 606 photos in the dataset that indicate human-driven land change, 172 (28%) include evidence of confirmed or suspected farming. Farming locations are clustered in the eastern areas of the park and along the border with Mexico.

Figure 9: Confirmed and Suspected Farming in SDL



Source: Author

Of the 172 images that indicated farming, we confirmed farming at 56 locations. The 56 confirmed farming locations are clustered in the south-east area of the park.

The eastern border of the park is experiencing population pressure. From this we would expect a similar distribution of farming locations along the border. But that is not what the data show. Instead, confirmed farming is clustered in the south-east and not evenly distributed along the eastern edge of the park. This indicates that there is a difference in land use patterns in the south-east area of the park and the area along the eastern border of the park. My analysis is that this cluster of confirmed farming locations in the south-east area of our study zone is an indicator of deforestation caused by population pressures.

Of the 172 images that indicated farming, we classified 116 points (67%) as suspected farming. The 116 suspected farming locations are more dispersed throughout the park compared to confirmed farming which was concentrated in the south-east area. These more dispersed suspected farming locations may indicate land speculation.

Mixed Farming and Ranching, Land Speculation

There are several land use scenarios where we expect to see combinations of farming and ranching together. When both farming and ranching are confirmed, this could indicate either a semi-subsistence farmer with a few head of cattle, or a ranch hand or guardian on a large ranch planting small-scale maize production or small orchards.

The spatial patterns of suspected farming and suspected ranching within SDL are similar, moving west-ward toward the center area of the park. While the spatial patterns are similar, this research indicates that the impact of ranching is greater. The overall number of suspected ranching locations (201) is greater than the number of suspected farming locations (116). Additionally, of the 172 images with confirmed or suspected farming, 157 also included evidence of confirmed or suspected ranching. That leaves only 15 data points that indicate farming (either confirmed or suspected) with no evidence of ranching. Conversely, there are 434 images that indicate confirmed or suspected ranching with no evidence of farming. The small number of stand-alone farming data points suggests that cattle ranching and not farming is the primary land use on illegally deforested lands in Sierra del Lacandón National Park.

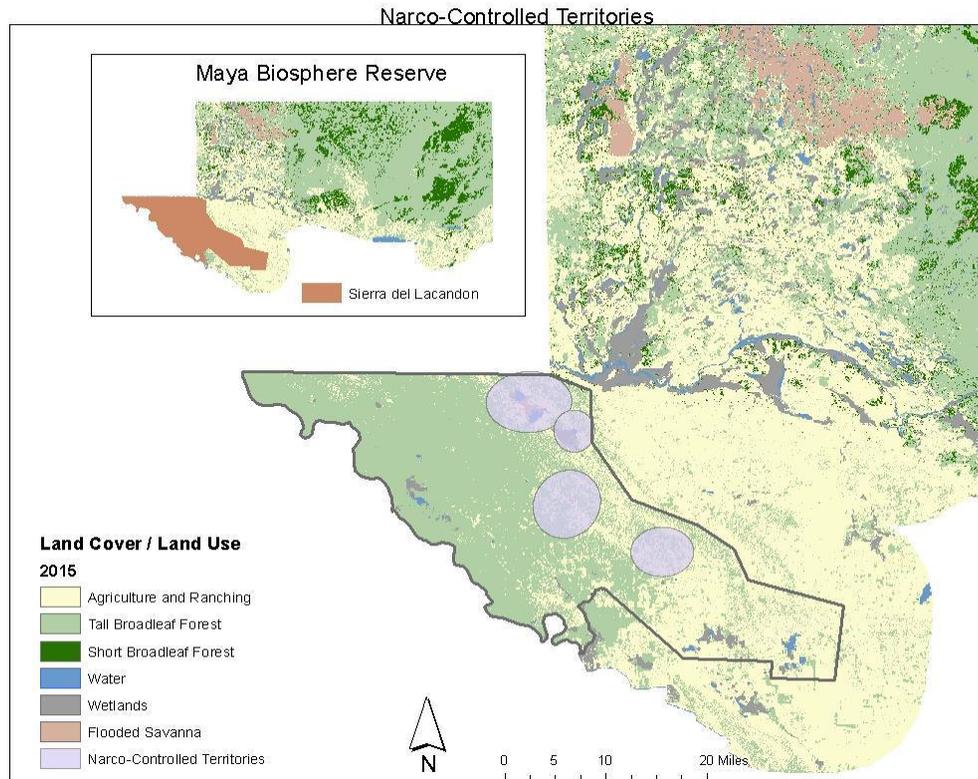
Suspected ranching and suspected farming locations may also indicate land speculation. Land speculation is “improvement” of land, clearing that can lead to

territory control and/or cattle ranching. These lands were once used for ranching or farming and then were abandoned, or they were cleared with the expectation of selling the land to ranchers. The latter category is a form of speculation. Land speculation can occur for a variety of reasons: illegally felling trees for timber sale, land “improvement” for sale to ranchers, and/or territory control for DTOs and other illegal actors.

Drivers of Deforestation: Narco-Deforestation

Sierra del Lacandón is a national park where Guatemalan law prohibits logging, farming, and ranching. However, these rules are only as strong as they are able to be enforced. In some areas, the activities of illicit actors have exceeded the ability of the administration to govern (Wrathall, et al. 2020). An anonymous protected area stakeholder shared an internal memo detailing narco-controlled territories in the Sierra del Lacandón National Park with members of our larger research team. The internal memo powerfully describes territory control by illicit actors and the means they use to gain control of land within the national park. The report lists cattle ranching as the main, but not only, cause of deforestation. It also explains the currently occurring systematic land-grab and expansion of territory. The report lists known areas that are narco-compromised. I digitized these narco-controlled territories identified in the report (see Figure 10).

Figure 10: Identified Narco-Controlled Territories in SDL



Source: Author

The memo explains that the actions of criminal groups in some areas exceed the capacity of the park administrators to respond. These “uncontrolled” areas threaten the integrity of the park. How did outside actors gain control of protected lands? Within the park, there are legal communities that have existed since before the park was formed in 1990. These communities were allowed to remain after the land was declared a national park and can legally reside with restrictions on land titling, ownership, and sale (Nations 2006). This complicated system has historically produced conflict between residents and park administrators. The more recent pressures of drug trafficking organizations vying for territory control exacerbated these underlying tensions.

The internal memo describes communities whose leaders have joined together in refusing to abide by the 1990 park agreement. The document asserts that these areas have joined with organized criminal groups and are operating outside of the control of park administrators. To be clear, not all residents of these communities are colluding with illicit actors. However, within these territories, park administrators are not able to safely pass, and these “ungovernable” lands are protected in name only.

The internal memo explains in detail ways in which deforestation is increasing through territory expansion. These include the growth of legal and illegal communities, illegal cattle ranching for both commercial use and land control purposes, the building of illegal roads and infrastructure to control territory and fragment park property, and illegal logging and extraction of mahogany and cedar.

As mentioned above, there are legal communities within the park boundaries that have regulations regarding land use. The expansion of existing communities through growth of new families and extension of community boundaries has increased deforestation. The internal memo also mentions cases of new illegal settlements. Both the expansion of existing communities and the creation of new settlements contribute to the “land grab” of park lands and land cover change from forest to agriculture or ranching.

A second means of territory expansion listed in the internal memo is illegal ranching. The authors of the memo indicate that ranching is the main source of deforestation in the park. My analysis of aerial photographs reached the same conclusion. The document explains that cattle are brought to the park for breeding and for illegal trade with Mexico. Additionally, ranching is part of the cycle of illegal buying

and selling of park lands. This is consistent with other research indicating that DTOs use cattle ranching for money laundering and territory control.

A third way that internal memo describes illegal territorial expansion is through the building of roads and infrastructure for territory control and fragmentation of park lands. The authors describe private roads with locked gates built to connect existing legal communities with new, illegal settlements. These areas are under local control of illicit actors who prohibit movement of authorities. Behind these locked gates, criminal groups are building infrastructure for large cattle ranching operations. While park authorities are aware of these activities, they do not have the ability to stop them.

A fourth method of illicit deforestation mentioned in the memo is the illegal extraction of mahogany and cedar. As with other illegal activities, there is coordination between criminal organizations and some community residents. Again, the memo mentions that the control of criminal organizations exceeds the ability of the park administrators to protect the park.

Drivers of Deforestation: Summary

The information from the internal memo combined with remote sensing data show that deforestation in Sierra del Lacandón is occurring in a variety of places for different reasons. Overall, cattle ranching is the largest driver of deforestation in the park. Of the 606 images that showed human-driven land change, 97.5% indicated either confirmed or suspected cattle ranching. While 28% of the images did include evidence of either confirmed or suspected farming, only 2.5% demonstrated farming with no

indication of ranching. The internal memo also names illegal cattle ranching as the largest driver of deforestation.

While cattle ranching is the largest driver, there is a difference between cattle ranching for subsistence and cattle ranching for territory control or money laundering purposes. The latter has a greater footprint in terms of land use change and environmental impacts. The spatial analysis of the WCS/CEMEC images combined with narco-compromised areas mentioned in the internal memo offer insight into the causes of deforestation.

The south-east area of the park, which borders an already largely deforested population center, has several areas of confirmed farming and confirmed ranching together. This area was not indicated in the internal memo as under the control of criminal organizations. The combination of confirmed ranching and farming, along with a lack of confirmed narco-presence, suggests that the deforestation in the south-east section of the study area is driven by population growth and territory expansion. This pattern is not indicative of land speculation or DTO cattle ranching.

The eastern border of the park has several confirmed ranching locations and few farming areas. These areas are specified as narco-compromised in the internal memo. The combination of confirmed narco activity and confirmed ranching without farming suggests deforestation driven by narco-cattle ranching and/or narco territory control.

The central area of the park, far from the population centers in the east, is also experiencing human-driven land change. This area has few confirmed locations of farming or ranching, but several areas of suspected ranching. This area is of particular

interest because it seems to indicate a frontier of deforestation in an area of the park that had been largely untouched previously (Figure 7 and Figure 8). This pattern of forest fragmentation, already present in the eastern areas of the park, is moving westward. There are more points of suspected ranching than suspected farming and we believe this “suspected ranching” category indicates narco-funded land speculation.

VI. CONCLUSION

This study contributes to a larger body of research quantifying the ecological impacts of narco-trafficking (Tellman, et al. 2020; Wrathall, et al. 2020; Devine, et al. 2020b; Devine, et al. 2020a). Exploring the impact of the drug trade on protected physical landscapes can give insight into the effectiveness of conservation governance and the threats facing protected lands. While these lands are all safeguarded in some way, the governance and management of the land varies by location. The impact of narco-deforestation is also highly variable.

In Sierra del Lacandón Park in Guatemala's Maya Biosphere Reserve, there are several drivers of deforestation. Land inequity and population pressures continue to drive frontier migration as subsistence farmers impact forest cover within the park. Both the remote visual analysis and local stakeholders have identified this type of encroachment into the protected areas from local communities. However, subsistence farming is not the main driver of deforestation in Sierra del Lacandón. The environmental impact of cattle ranching and land speculation is much greater.

Local stakeholders have confirmed that areas of the park are narco-controlled. Territory control by illicit actors has resulted in "ungovernable" areas of the national park where conservation measures exist in name only. The identified narco-controlled areas are experiencing high rates of deforestation from cattle ranching. Additionally, the central area of the park, adjacent to the identified areas of narco-activity, is experiencing deforestation and forest fragmentation in a pattern that indicates land speculation. This area had not previously been impacted by deforestation

and this research suggests land speculation and cattle ranching, likely with ties to drug trafficking organizations, are the frontier of deforestation within the park.

The broad goal of this work is to raise awareness of the environmental impacts of international drug policy. Drug policy and conservation policy are inextricably linked. Interdiction has not reduced the flow of drugs, but it has increased narco land grabs and deforestation. Conservation efforts to stem forest loss in Central America must address the threat of narco-deforestation and include change in US drug policy.

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