Deforestation and Migration in Colombia

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International Relations Honors Thesis
New York University
Spring 2021

Abstract

This paper seeks to determine how deforestation influences out-migration in Colombia. The Amazon Rainforest is known as the "lungs of the earth" because its vast forest coverage filters a significant amount of carbon dioxide, one of the main greenhouse gases that contribute to climate change. Considering this, deforestation accelerates and exacerbates the adverse effects of climate change that can influence economic and social life. Hence, this paper looks at population changes as an outcome of deforestation. To examine this relationship, I analyze population changes across 950 municipalities in Colombia from the years 2002 to 2017. I find that there is an overall positive relationship between deforestation and population across the board, especially in the urban centers of municipalities. Thus, deforestation causes the population to rise in cities through migration from rural to urban areas. Furthermore, this paper explores the theory behind this relationship and finds more nuanced results pertaining to areas with high concentrations of deforestation or high indigenous population density. Deforestation clearly has a noteworthy effect on the lives of Colombians that will only escalate over time.

1. Introduction

Too often, media coverage and academic research neglect the human experience of climate change. Statistics about pollution and natural disasters are widely discussed; rarely, however, aside from direct deaths or generalized claims, do these figures address the true human costs of climate disaster. Climate change exacerbates pre-existing vulnerabilities in society and marginalizes precarious groups such as Indigenous peoples, People of Color, migrants, and impoverished populations. Therefore, social justice and environmental justice are inherently intertwined.

The United Nations High Commissioner for Refugees (UNCHR) acknowledges the existence of climate change related displacement, but the term "climate refugee" does not exist in codified international law. Since the foundation of these laws lies in the 1951 Refugee Convention and the updated 1967 Protocol, it is clear that the definition of a “refugee” must adapt to fit both our changing society and changing climate. However, the UNCHR does recognize the existence of "nexus dynamics", which refers to the intersection between conflict or violence and "adverse effects of climate change" (UNHCR). It is important to note that the effects of climate change are innately correlated with economic opportunities and resources, yet economic migrants are not eligible for asylum. More so, migrants are only eligible for asylum or refugee status once they cross state borders. As such, this fails to acknowledge internally displaced populations seeking refuge within their own country. This paper explores the “nexus dynamics” by analyzing the relationship between deforestation and migration within and across Colombian municipalities.

I chose to look at Colombia as a case study for various reasons. While Brazil is the main culprit of extreme deforestation in the Amazon Rainforest, Colombia, Bolivia, and Peru also play a significant role (Butler). The Amazonian region has been exploited for its rich resources since the early days of Spanish and Portuguese colonization. Colonial practices of resource extraction through the *encomienda* labor system have transformed into a globalized competition of exploitation. Furthermore, deforestation fosters this cycle of colonization that emphasizes capitalism and profits at the expense of human lives. The drivers of deforestation vary from region to region: in the case of Colombia, deforestation is primarily linked to cattle ranching, coca production, illegal mining, and palm oil cultivation (Butler).[1] While the factors driving deforestation appear to be beneficial to the global economy, the harm of deforestation greatly outweighs any short-lived economic success.

For example, deforestation jeopardizes the general ecosystem as it destroys natural habitats, disrupts the water cycle, erodes soil, increases greenhouse gas emissions, among other consequences ("Effects of Deforestation"). Also, Colombia is the second most biodiverse country in the world, hosting 51,330 species of plants and animals (around 10% of the world's biodiversity) (Colombia.Co). Although the Colombian government has taken steps to address the conservation of biodiversity, these efforts will be in vain without serious sanctions on deforestation practices.

In addition to disrupting the ecological environment, deforestation alters the human experience. This paper intends to approach this phenomenon empirically. Moreover, indigenous populations are disproportionately affected by deforestation and its effect on climate change. According to census data from the Colombian government, the indigenous population in Colombia increased by 36.8% from 2005 to 2018 and now constitutes 4.4% of the total population (DANE). A majority of the indigenous population in Colombia reside in designated

[1] The leaves of coca plants are used to create cocaine.

territories where they have a high level of sovereignty. In 2009, the Colombian government endorsed the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) which guaranteed that the United Nations Declaration of Human Rights (1948) applied to indigenous populations (UN General Assembly). The UNDRIP also built upon the 1948 document to cater specifically to the precariousness of indigenous peoples. Article 8.2 of the UNDRIP states that:

> "States shall provide effective mechanisms for prevention of, and redress for… (b) Any action which has the aim or effect of dispossessing them of their lands, territories or resources; (c) Any form of forced population transfer which has the aim or effect of violating or undermining any of their rights" (UN General Assembly 4).

Indigenous people's rights to their territory are codified in international and Colombian law, yet these populations are still disproportionately affected by conflict and deforestation. My paper will continue to build on this theory.

The main objective of my research is to discover and analyze the relationship between deforestation and migration by looking at population changes in Colombian municipalities over the span of 15 years (2002-2017). Deforestation itself is not an effect of climate change due to its artificial and man-made nature, but rather an influential cause of adverse climate effects in South America. Therefore, one could hypothesize that areas with high levels of deforestation experience higher levels of out-migration as populations seek to escape a turbulent and inhospitable climate. On the other hand, an increase in deforestation could alter the socioeconomic environment of a municipality by creating more opportunity yet conversely stripping purchasing power from the average actor in the economy. Especially in the case of Colombia and surrounding Latin American countries, narcotrafficking and other illicit economic activities are highly linked to the socio-ecological composition of a municipality. The cultivation of illicit crops can stimulate economic activity, but it can also lead to aggressive land grabbing and unstable markets (Clerci, et al. 2). This paper investigates this economic dichotomy through the outcome of migration and population changes.

My research differs from the recent literature surrounding migration and displacement in Colombia by looking specifically at deforestation as the treatment variable while conflict is merely a confounding variable. Levels of deforestation are not distributed equally; therefore, acknowledging the difference between municipalities with no deforestation versus extreme deforestation is quite important. By implementing a marginal effects analysis into my empirical design, I am able to isolate municipalities that experience high levels of deforestation and exclude municipalities that are fully urban with no deforestation.

Through my research, I find a positive relationship between deforestation and municipal populations. These population increases include both in-migration and out-migration, thus suggesting that deforestation plays a role in the movement of people across Colombia. This result is even stronger in urban areas, thus affirming theories of increasing rural to urban migration. Overall, my results uphold the notion that deforestation has a strong influence on the movement of people in Colombia. This research does not prescribe policy, but rather explores the motivations behind the movement of people, particularly rural to urban migration. While migrants make the conscious choice to leave their homes, there are factors out of their control, like deforestation, that influence their movements, whether they know it or not.

2. Literature Review

2.1 Deforestation in Colombia

Literature concerning deforestation in the Amazon is quite common. Colombia serves as a unique case study due to its long history of conflict, presence of illicit economic activities, and its proximity to the Amazon rainforest. This paper builds on the results of two recent papers: Prem, Saavedra, and Vargas (2020) and Clerci et al. (2020). Both papers look at the effects of conflict on deforestation in Colombia by utilizing the Global Forest Change dataset (Hansen et al. 2013) to determine forest coverage. While Clerci et al. (2020) specifically targeted the Protected Areas (PA), both studies found that, in general, there was an increase in deforestation following the beginning of the peace process.

My paper focuses on the time period 2002 to 2017. During this period, Colombia experienced a slow burn toward peace. Since the 1960's, non-state paramilitary groups, like the *Fuerzas Armadas Revolucionarias de Colombia* (FARC), have destabilized aspects of the Colombian government and economy (Prem, et al. 2). Ch et al. (2018) defines 2003 to 2006 as a period of "paramilitary demobilization" and 2007 to 2010 as a period of "state resurgence" (11). In October of 2012, Colombia began taking strides toward a peace agreement with the FARC; a process that lasted four years (Prem, et al. 2). This history of conflict holds a crucial role in studies of deforestation and migration in Colombia.

Clerci et al. (2020) begins to touch on the idea of this paper by acknowledging how conflict can cause the displacement of people, a " 'refugee effect', [that] can prove beneficial for habitat and biodiversity protection, e.g., by limiting the pressure of resource extraction" (1). In addition, they discuss the 'Victims and Lands Restitution Law' and the Land Restitution Unit. This policy states and enforces that those dispossessed of their land during conflict have a right to restitution. Subsequently, population and economic activity increased in these previously violent areas as people return to their homeland. Considering this and the fact that Colombia historically struggles with enforcing land use policy, the trend of increased post-conflict deforestation is expected. However, what happens to these new deforestation hubs next? Clerci et al. (2020) does not expand on the subject of migration in the way this paper aims to do.

Both Prem, Saavedra, and Vargas (2020) and Clerci et al. (2020) consider the peace process as a mechanism for deforestation. Clerci et al. (2020) uses a before-and-after research design by examining the three years before the peace agreement (2013, 2014, and 2015) and the three years after conflict (2016, 2017 and 2018). Their main finding confirms their hypothesis in that 79% of Protected Areas experienced an increase in deforestation in the three post-conflict years. On the other hand, Prem, Saavedra, and Vargas (2020) utilize a difference-in-differences research design in order to compare deforestation at the municipal level throughout the years of the peace process negotiations that began in 2012. They conclude that areas previously occupied by the FARC experienced an increase in deforestation following the cease-fire announced in 2014.

Like Clerci et al. (2020), Hoffman and Grigera (2013) discuss the lack of effective policy enforcement in Colombia in relation to climate change and conflict, while analyzing migration as well. Coca production flourishes under weak state presence. In order to combat the hold that illicit drugs have on the South American economy, specifically in Colombia, there must be sustainable economic development and coinciding enforcement of the law. For example, the United States attempted to tackle narcotrafficking by assisting in "Plan Colombia". The U.S. sent hundreds of millions of dollars, "to train and equip Colombian counternarcotics battalions to protect the Colombian National Police" and to fund development through "technical and agricultural support to farmers in southern Colombia" (Hoffman 15). Although efforts like this led to a 50 percent decrease in coca crops in Colombia, sustainable economic development requires more than just anti-drug trafficking policies. Governments should also invest in preventative agricultural research and “social programs to help increase entrepreneurship and wean poor farmers off coca cultivation by incentivizing legal livelihoods” (Hoffman 15). In addition to agricultural related development, Hoffman and Grigera (2013) emphasize the importance of “livelihood diversification and training in nonagricultural skills” so rural communities are not solely dependent on agricultural production income (92). While this could increase migration “to urban areas or different peripheral areas, migration is a proactive adaptive strategy that should not necessarily be seen as a negative outcome” (Hoffman 92). Hoffman and Grigera (2013) provide the policy prescriptions that relate to the outcome of my research.

2.2 Palm Oil

Deforestation can be difficult to measure when natural forest coverage is replaced by other vegetation, such as palm oil trees. According to *Amazon Frontlines*, an organization that defends indigenous communities and the Amazon Rainforest, “palm oil plantations have more than doubled in Latin America since 2001” (Webb).[2] While these trees still participate in the carbon and water cycle, deforestation utterly disrupts and destroys biodiversity and surrounding communities. At the same time, palm oil cultivation is a lucrative industry and could create economic opportunities (Webb). Thus, it is no surprise that palm oil production influences migration. Sabogal (2013) finds a positive correlation between palm oil cultivation and displacement in Colombia. However, Sabogal (2013) does not evaluate the theory and mechanisms that could confirm a causal relationship — something my research attempts to introduce. While Sabogal (2013) analyzes the role of armed groups in Colombia, this paper was published three years before the official bilateral ceasefire in 2016.

2.3 Land Law

[2] *Amazon Frontlines* refers to a 2017 paper on palm oil in Latin America that can be found at https://iopscience.iop.org/article/10.1088/1748-9326/aa5892/meta.

Colombia has a lengthy and complex history of land distribution due to volatile economic and conflict-related factors. According to Oxfam Colombia, "the top 1 percent of large farms account for 81 percent of the country's productive land while the other 19 percent of land is split among the remaining 99 percent of small landholders" (Volckhausen).[3] Throughout the enduring conflict with the FARC, many Colombians were displaced and were forced to leave their homes. In attempts to resolve the conflict and pursue justice and equity, the Colombian government passed the Victims and Land Restitution Act (Law 1448) in 2011.[4] The main goal of this law was land restitution rights. Although the Land Restitution Unit reported returning "291,000 hectares of state lands… to nearly 37,000 displaced individual farmers, as well as to indigenous and afro-Colombian groups," in 2018, there are still "7.4 million displaced *campesinos*" in Colombia (Volckhausen).[5] However, the Colombian government is still determined to improve land distribution. In 2016, President Juan Manuel Santos passed a highly debated law that would "allow for the formation of Rural, Social, and Economic Development Zones (ZIDRES)" (Volckhausen). In theory, ZIDRES sound like a good idea, but in practice palm oil-supportive ZIDRES will fail to contribute to the goal of environmental conservation and the protection of biodiversity. Instead of helping the *campesinos* of rural Colombia and protecting indigenous territory, ZIDRES "effectively 'legalize the accumulation of land" that agribusiness interests 'illegitimately obtained during the armed conflict' at the cost of the country's *campesinos* and autonomous ethnic groups who still have individual and collective land restitution cases pending injunctions" (Volkhausen). Aggressive agribusiness expansion requires the clearing of forests, so

[3] Oxfam International is a non-governmental organization (NGO) dedicated to fighting poverty and injustice in Colombia. More information about the organization can be found at https://www.oxfam.org/en/what-we-do/countries/colombia
[4] More information about the goals, progress, and shortcomings of Law 1448 can be found at https://www.tni.org/es/node/1383
[5] "*Campesinos"* is a Spanish term used to refer to farmers or natives of a rural area in Latin America.

my analysis includes effects of deforestation specifically in areas with a high indigenous population density. It is important to note that my analysis only encompasses one year of the ZIDRES law in practice. It is possible that this law will shift the long-term relationship between deforestation and migration.

2.4 Migration & Climate Change

This paper follows the thematic approach of Wellink, L.C. (2013) which investigates the relationship between deforestation and migration in Brazil. Deforestation and other invasive economic activities have contributed to an increase in droughts and land degradation in the Amazon region. Wellink, L.C. (2013) includes droughts and land degradation as independent variables in their research. The main findings of this paper state that areas with high drought levels experience a higher rate of out-migration while areas with high deforestation experience the opposite effect. Wellink, L.C (2013) noted the presence of economic factors as a mechanism for this relationship because "deforestation decreases out-migration as the effect on labor demand surpasses the effect of people being harmed by deforestation" (21). In my research I intend to challenge the external validity of this claim by applying a similar question to Colombia. As stated earlier, deforestation and destructive agricultural practices lead to adverse climate challenges such as droughts and desertification. Therefore, a negative relationship between out-migration and deforestation might not always be the case.

2.5 Rural flight

In his 2010 book about the social implications of climate change in Latin America, Dorte Verner affirms that deforestation causes land degradation, desertification, decreased rainfall, and more. While deforestation may allow for temporary economic gains, this growth is not exponential. Land degradation leads to nutrient depletion thus devaluing the land and contributing to the poverty cycle. Factors like these could cause out-migration in the long-run. While my research is unable to encompass a long period of time following the resolution of the Colombian conflict, it is clear that my research question will grow in importance over time. Also, as I intend to investigate demographic characteristics pertaining to migration such as poverty levels and indigenous population density, Verner's publication provides essential information about the heterogeneous effects of climate change on various populations. The World Meteorological Organization (WMO) builds on this concept in a 2020 article about the impact of climate change on migration in South America. They state that the influx of migrants to urban centers has increased the presence of informal urban settlements which leaves present and future internally displaced peoples (IDP) in a precarious situation (Warn and Adam). Therefore, I will quantify this trend by analyzing rural to urban migration and its respective relationship to deforestation.

Due to Colombia's unique experience with armed conflict and illegal actors, there is an array of literature about forced migration in Colombia. For example, in a 2010 issue of *Forced Migration Review*, Sebastián Albuja and Marcela Ceballos discuss urban displacement in Colombia. At the time, Bogotá, the capital and largest city in Colombia, hosted roughly 270,000 IDP (Albuja and Ceballos 10). In addition to this IDP population, Bogotá also houses the largest immigrant population in Colombia (Albuja and Ceballos 10). According to Albuja and Ceballos (2010), this large number of IDP and immigrant populations are linked to "the same root cause: rural-urban migration which has historically been driven by unequal access to land and [consequent]... tension between land-owners and peasants and eventually to the armed conflict and violence that continue to cause forced displacement" (10). Such factors contribute to the nexus dynamics of conflict and climate change that surround the main topic of my research.

3. Theory and Hypothesis

This paper theorizes that deforestation influences out-migration, or higher population changes. This is based on the assumption that deforestation can cause adverse effects of climate change that would motivate voluntary migration movements or forced displacement. Both Prem, Saavedra, and Vargas (2020) and Clerci et al. (2020) confirm that the years following conflict in Colombia have seen an increase in deforestation. Invasive deforestation continues due to a lack of effective enforcement of environmental policy, which threatens biodiversity, climate patterns, and overall degrades the land's organic and economic value. While the term "climate refugee" does not exist in codified law, it is clear that governing bodies, like the United Nations, acknowledge the nexus dynamic that climate change creates for migrants. Most likely, deforestation is not the direct cause of displacement or out-migration, but rather a catalyst for other push factors of migration. It is quite possible, however, that deforestation does cause out-migration as well. To reiterate, deforestation is linked to many ecological and economic factors that could affect the movement of people. This theoretical deduction leads to the following general hypothesis:

> H_{A1}*: Municipalities that experience high levels of deforestation will likely experience an increase in out-migration.*

Within my empirical design, out-migration is represented by population changes at the municipal level. Since these migrants might be relocating to another municipality or department within Colombia or even to a different part of their original municipality, measuring out-migration becomes much more complex. Therefore, it is important to investigate where these migrants will go. I believe one of the most influential mechanisms for the relationship between deforestation and migration is rural flight. If rural areas are being invaded by destructive economic practices, then it is likely that people would migrate to urban areas. This leads to my secondary, more targeted, hypothesis:

H_{A2}: Municipalities that experience high levels of deforestation will likely experience an increase in the population of their urban centers and highly populated municipalities will experience a rise in population in general.

There are several mechanisms that could explain this link between deforestation and migration. According to Prem, Saavedra, and Vargas (2020), one of the reasons that deforestation increased after the peace process began was because areas previously occupied by the FARC could now be used for illicit farming, like cocaine production (10). Another reason for increasing deforestation is cattle ranching. Verner cites Nepstad et al. (2008) in stating that 70 percent of deforestation in the Amazon is due to the encroachment of cattle ranchers (Verner 100). Both of these economic practices could influence the movement of migrants. While cattle ranching is not labor intensive, it does have the potential to provide economic activity in a newly deforested area. Therefore, my research will utilize the control variables from Prem, Saavedra, and Vargas (2020) pertaining to cattle and cocaine suitability to consider these economic practices as mechanisms for the causal relationship between deforestation and migration. I also plan to use these variables in a separate mechanisms test.

Nevertheless, this theory does not assume that out-migration is a universal outcome of areas with high deforestation. Migration is not always a viable option for vulnerable populations. This leads us to my third and final hypothesis:

H_{A3}: When deforestation levels increase, municipalities with a high density of indigenous populations will likely experience a lower rate of out-migration.

Also, in the case of indigenous populations, it is possible they would be territorial of their native land and brave the adversity that deforestation-induced climate change can bring instead of migrating somewhere new. Therefore, it is quite possible that due to either temporary economic gains or the inability to migrate, out-migration could decrease in areas where deforestation increases.

While deforestation eradicates the natural forest coverage of indigenous territories, it also creates a ripple effect of precariousness. Around 80% of indigenous populations live in rural areas and likely rely on agricultural production to support their livelihood (Valencia Otova 381). As stated earlier, deforestation causes desertification and droughts. Without sufficient tree coverage, the water cycle is completely disrupted. The roots of the trees retain water which aids in irrigation and prevents excessive flooding. Then, this water progresses in the cycle and returns to the atmosphere through evapotranspiration ("The Fundamentals of the Water Cycle"). This leads to decreased annual rainfall and consequent droughts and desertification. Since a significant amount of the indigenous population depends on cultivation of the land, soil depletion due to droughts from deforestation leads to lower and inconsistent crop yields thus threatening the livelihoods of these populations.

In addition to the economic repercussions, deforestation can create a biohazard risk for surrounding communities. Damage to agricultural production also threatens local communities' "food sovereignty" meaning people have less control over their own food and respectively, their health and well-being (Weiler, et al. 1080). Also, when natural forest cover is replaced by coca or palm oil plantations, companies use pesticides and fertilizers that contaminate the ecosystem and create unknown levels of harm for indigenous communities (Webb).

On one hand, indigenous populations are greatly impacted by deforestation and subsequent climate change. On the other hand, these indigenous groups are partaking in environmental harm reduction and climate activism. Clearly, the Colombian government and other surrounding Amazon states must take immediate action to prevent further deforestation while also listening to the voices of the precarious – indigenous communities. In order to emphasize this phenomenon, I will isolate municipalities with high levels of indigenous populations through the usage of a binary, dummy variable in my regression model and therefore analyze the heterogeneous effects of the outcome.

4. Empirical Design and Data

In Colombia, there are 1,123 municipalities. However, reliable deforestation data was only available from 950 municipalities over 15 years (2002 to 2017). While Hansen et al. (2013) has continued to update the Global Forest Change (GFC), data specific to the municipality level in Colombia is most compressive and applicable for this subset of years and municipalities.

Table 1 below displays the descriptive statistics of the treatment, outcome, and control variables that are included in each regression equation. This table does not include any of the variables used for municipality or years fixed effects such as municipal area in square meters.

Table 1: Descriptive Statistics of Treatment, Outcome, and Control Variables

Statistic	Mean	St. Dev.	Min	Median	Max
Deforestation (m^2)	2,384,540.000	9,774,124.000	0	413,100	344,856,600
Total Population	42,680.840	260,350.400	813	13,407	8,080,734
Urban Population	32,461.660	258,636.200	54	4,729.5	8,063,991
Rural Population	10,219.180	10,818.640	172	7,171	173,143
Number of FARC attacks (2011-2014)	0.417	2.245	0	0	52
Dummy indicator for FARC presence in neighboring municipality	0.308	0.462	0	0	1
Dummy indicator for the ceasefire period (2014-2017)	0.188	0.390	0	0	1
State Presence Index	14.129	4.100	7	13.7	100
Log of distance from nearest military base	-0.064	0.946	-4.610	0.114	2.977
Tax Revenues	-2.677	0.922	-6.908	-2.677	0.525
Poverty Index	0.685	0.157	0.143	0.698	1.000
Coca Suitability Index	0.011	1.008	-1.575	-0.077	3.007

Table 1 Notes: This table presents summary statistics for the independent, dependent, and control variables. Each variable contains 16,288 observations that include data from 2002-2017 across 950 municipalities in Colombia. *Deforestation* includes the municipal deforested area in square meters over the 15-year time span of analysis (2002-2017). *Total Population, Urban Population, and Rural Population* include census data and estimations of Colombian municipalities from the National Administrative Department of Statistics (DANE). *State Presence Index* represents the average number of public offices, such as courts, per municipality as calculated by Acemoglu et al. (2015). For *Log of distance from nearest military base,* military base is defined as a military unit with at least 3,000 soldiers. The number used for *Tax Revenues* is the logarithm of real capita 2010 tax income in a municipality. *Poverty Index* is calculated through the multidimensional poverty index in the 2005 census. *Coca Suitability Index* is a measurement from Mejia and Restrepo (2015) of coca soil and climate suitability in a municipality. More information about the dependent and control variables, please refer to Prem, et al. (2020).

4.1 Independent Variable

In my research, deforestation ($Deforestation_{mt}$) serves as a symbolic measurement of climate change. Deforestation is not directly a result of climate change but rather a cause of adverse climate change effects. Therefore, areas with high areas of deforestation will likely experience harsher effects of climate change compared to areas where there is little change in forest coverage. However, we cannot neglect the fact that deforestation is, at its core, an economic practice. Thus, areas with high levels of deforestation can also become hot spots for migrants seeking economic opportunities. However, economic practices centered around deforestation are not sustainable. They produce temporary economic success while leading to long-term harm to the environment. This is why I chose deforestation as the independent variable in this study on migration in Colombia.

When studying deforestation, it is important to acknowledge potential sources of measurement bias. At the surface level, the variable, deforestation, should represent loss of forest coverage. However, in academia, there are discrepancies in deforestation measurements. Most research studying deforestation utilize the Global Forest Change (GFC) dataset project from Hansen et al. (2013). Fergusson, Saavedra, and Vargas (2020) analyze the issues of deforestation data. In their paper, Colombia serves as a case study since deforestation data can derive from GFC and an alternative dataset from IDEAM (Colombia's Institute of Hydrology, Meteorology and Environmental Studies). Fergusson et al. (2020) uses these two sources to compare and contrast measurements of deforestation. One of the most important differences is that the GFC dataset includes palm oil trees in their calculation of forest coverage. Palm oil plantations are one of the leading causes of deforestation in Colombia and much of the Amazon (Webb). As shown in *Figure 2*, these plantations disrupt natural forest cover and threaten biodiversity. Nevertheless, palm oil trees are still trees, thus contributing to the GFC calculation of forest coverage. My research study utilizes deforestation data from Prem, Saavedra, and Vargas (2020) which addresses the presence of differing measurements of deforestation. After using the GFC dataset from Hansen et al. (2013) to aggregate pixels of tree cover at the municipal level, Prem, Saavedra, and Vargas (2020) defines deforestation as "the deforested area in a given municipality/year relative to the entire forest area of that municipality in 2000" (Prem et al. 4).[6] In my regression model, I utilize the logarithmic transformation of the GFC deforestation data.

Figure 2: While palm oil plantations are counted in the forest coverage calculation, natural forest cover must be cut down in order to create room for the new trees. *Source: Amazon Frontlines*

4.2 Dependent Variable

The dependent variable of my research study, out-migration ($Population_{mt}$), is measured by the population change in municipality from year to year. Within the regression model, a logarithmic transformation is applied to the municipal population data (total, urban, and rural). The total population encompasses the entire municipality, while urban and rural are defined by thresholds at the municipal level.[7] Each municipality contains figures for the total, urban, and

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[6]From Prem, Saavedra, and Vargas (2020): "Tree cover is defined as all vegetation higher than 5 meters of altitude, irrespective of the canopy density. Deforestation (or tree cover loss) is coded as the complete removal of tree cover canopy at the pixel level from one year of measurement to the other" (4).

[7] The DANE defines "urban" (*cabecera*) as *"el área geográfica que está definida por un perímetro urbano, cuyos límites se establecen por acuerdos del Concejo Municipal. Corresponde al lugar en donde se ubica la sede administrativa de un municipio"* [the geographic area that is defined by an urban perimeter, whose limits are established by agreements of the Municipal Council. It corresponds to the place where the administrative administrative headquarters of a municipality is located] (https://www.dane.gov.co/files/inf_geo/4Ge_ConceptosBasicos.pdf).

rural population. Nonetheless, migration data also possesses its own forms of measurement bias. Data for population at the municipal level in Colombia comes from *el Departamento Administrativo Nacional de Estadística* (the National Administrative Department of Statistics), or DANE. The Colombian government has conducted official censuses in 1964, 1973, 1985, 1993, 2005, and 2018. Therefore, in order to have a large enough data pool I used the yearly estimates provided by DANE, specifically the years 2002-2017 to coincide with my dependent and control variable data. Since the non-census years are estimations, it is possible that there are some measurement inaccuracies. Because out-migration is measured by population change, it is possible that changes in population encompass other factors. This is why the presence of control variables are essential in my research design.

4.3 Controls and Other Variables

When looking at the relationship between deforestation and population change, there are many confounding variables. Colombia has a history of weak state presence in rural areas as well as 50 years of intrastate conflict — both factors that influence deforestation and migration patterns.

One of the most influential and concerning confounding variables in this study is the presence of violence from armed groups. It is important to note that in addition to conflict-based displacement due to violence and destruction, FARC presence creates economic confounders that can affect migration after the peace process. According to Prem, Saavedra, and Vargas (2020) when FARC presence decreased in a municipality, deforestation increased — likely due to an upsurge of farming illicit crops and cattle ranches as well as internally displaced peoples returning to their land. In order to ensure my results were not only due to conflict-based displacement I applied controls for conflict to the two-way fixed effects regression. For the controls in my regression equation, I use the measurements for conflict from Prem, Saavedra, and Vargas (2020). In addition, I utilized the same regression to compare two subsets of the data: before and after the beginning of the peace process. The FARC and the Colombian government began their peace process in October 2012. In this study, "before the peace process" is defined as 2002 to 2012, while "after the peace process" includes data from 2013 to 2017.

FARC presence is defined by the number of violent attacks from 2011 to 2014 (since the peace deal became official in 2014). If a municipality is "above the 10th percentile of the empirical distribution of places with at least one event" then it is defined as having FARC presence. The same calculation applies to the dummy indicator for FARC presence in neighboring municipalities.

Another important confounder in this study is state capacity. A weak state presence can lead to lawlessness, violence, and a lower quality of life. This serves as an important push-factor in migration patterns while high state capacity and a well-functioning government can be a pull-factor for migrants. State capacity also affects deforestation practices through the enforcement of environmental law and policy. In this study, state capacity is measured by the following: tax revenues, log of distance to the nearest military base, multidimensional poverty index, and a general index of state presence from Fundación Social. *State Presence Index* represents the average number of public offices, such as courts, per municipality as calculated by Acemoglu et al. (2015). For *Log of distance from the nearest military base,* a military base is defined as a military unit with at least 3,000 soldiers. The number used for *Tax Revenues* is the logarithm of real capita 2010 tax income in a municipality. *Poverty Index* is calculated through the multidimensional poverty index in the 2005 census. In addition to the state presence variables, I control for specific environmental conditions with the *Coca Suitability Index* measurement from Mejia and Restrepo (2015) that constitutes coca soil and climate suitability in a municipality.[8]

Migration and deforestation are both highly influenced by state presence. If there is a weak state presence, low enforcement of land policy, and weak infrastructure, the average citizen tends to struggle to secure long-term economic opportunities in an unstable market. For this reason, Colombia has a 79% rural poverty rate (Vernor). Oftentimes, these rural communities are left with two options: migrate or resort to clearing forest land for agricultural pursuits "or more profitable illicit activities" (Clerci et al. 2). It is possible that migrants that were displaced due to conflict may return to their former lands, via the Land Restitution Unit, and pursue new economic ventures that were unavailable under FARC occupation. All these confounding variables are accounted for in the empirical design and represented by $X_{mt}\theta$ in *Equation 1*.

Equation 1: Regression Equation

$$\textit{Population}_{mt} = \alpha_{mt} + \beta \textit{Deforestation}_{mt} + \delta_m + \lambda_t + X_{mt}\theta + \varepsilon_{mt}$$

This study analyzes the effect of deforestation on migration in Colombia. To do so I utilize a two-way fixed effect model that accounts for invariance across years and municipality (represented by δ_{mt} and λ_{mt} respectively in *Equation 1*). By looking at the municipal level, we are able to consider interstate, intrastate, and intra-municipal migration. Population_{mt} represents the outcome variable: municipal population. Each regression model is run at least three times to account for the varying outcome variables: total, urban, and rural population (all within the same municipality). $\textit{Deforestation}_{mt}$ is the independent variable (or treatment) and is measured by the logarithmic transformation of loss of forest coverage per year in each municipality (See section

[8] For more information about the dependent and control variables, please refer to Prem, et al. (2020).

4.1 for more details). δ_m and λ_t respectively represent municipality and time fixed effects. $X_{mt}\theta$ represents the control variables described in *Section 4.3* (Number of FARC attacks (2011-2014), Dummy indicator for FARC presence in neighboring municipality, Dummy indicator for the ceasefire period (2014-2017), State Presence Index, Log of distance from nearest military base, Tax Revenues, Poverty Index, Coca Suitability Index).

5. Results

5.1 Main results

Table 2: Main Regression Results

	Outcome: Log of Municipal Population											
	Total				Urban				Rural			
	2002-2017	2002-2017	2002-2012	2013-2017	2002-2017	2002-2017	2002-2012	2013-2017	2002-2017	2002-2017	2002-2012	2013-2017
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Log of Deforestation	0.027***	0.016***	0.021***	0.011***	0.030***	0.019***	0.029***	0.015***	0.018***	0.010***	0.013***	0.009***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.003)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Observations	16,288	16,288	11,198	5,090	16,288	16,288	11,198	5,090	16,288	16,288	11,198	5,090
R^2	0.954	0.977	0.978	0.980	0.957	0.977	0.978	0.978	0.936	0.959	0.962	0.967

Table 2 Notes: This table presents the main regression equation. All regressions include municipality and time fixed effects. The years 2002-2012 refer to the period before the start of the peace process in 2012, while 2013-2017 represents the period after the peace process began. The outcome variable is the log of population (*Total*, *Urban*, and *Rural* are all within the same municipality). The independent variable, *Log of Deforestation*, is derived from the GFC database (Hansen, et al. 2013) and represents the log of deforestation in square meters at the municipality level. Deforestation is calculated by a proportion of deforested area in a municipality in year t relative to the forest coverage of a municipality in 2000 (the first year provided by Hansen et al. (2013)). Controls added to the original regression include index of state presence, distance to nearest military base, FARC presence in municipality or neighboring municipality, Tax

Revenues, Multidimensional Poverty Index, and Coca suitability index. More information about the controls can be found in *Table 1*.
*p < 0:10; **p < 0:05; ***p < 0:01.

After controlling for time and municipal fixed-effects, we are left with a positive relationship between deforestation and migration. By adding controls, the coefficients dropped as should be expected, yet remained positive (See Columns 2-4, 6-8, 10-12). Column 2 indicates that a one percent increase in deforestation should result in a 0.016% increase in the mean of total municipal population. In a way, this denies my original hypothesis (H_{A1}) that municipalities that experience high levels of deforestation will likely experience an increase in out-migration. However, my prediction still prevails since there was still an increase in migration in general (in-migration *and* out-migration) across Colombian municipalities. This is not a surprising result. As stated in the literature review (*Section 2)*, although deforestation disrupts the environment, it does provide short-term economic growth and opportunity. My study encompasses 15 years and only includes one year after the official peace accords in 2016. The effects of the enduring conflict with the FARC are still intertwined with my results, despite controlling for FARC presence and other state factors. Many Colombians were displaced during the conflict and are now returning to their original land. This is due to attempts by the Colombian government to codify land restitution, such as the Victims and Land Restitution Act (Law 1448) . However, laws governing land are not well enforced, especially in rural areas. These movements are also increased and influenced by the rise of illegal activities in previously FARC controlled lands. Although my results did not completely support my original hypothesis, that does not mean the results are not meaningful. In the long-term, the adverse effects of climate change, like land degradation, droughts, and desertification, will alter the human experience in Colombia. While deforestation may allow for temporary economic gains, this growth is not exponential. Land degradation leads to nutrient depletion thus devaluing the land and contributing to the poverty cycle.

5.2 Rural Flight Results

Despite the fact that deforestation could entice movement to more rural areas, we see the strongest relationship between deforestation and rural flight (or relocation to highly populated centers within a municipality) in Columns 5-8 in *Table 2.* Municipalities in Colombia vary in their area, so it is quite possible that people can migrate *within* a municipality. To account for this phenomenon, my study incorporates regressions using the log of urban population and rural population within a municipality. With controls, a one percent increase in deforestation results in a 0.019% increase in the average urban population (See Column 6). This result supports my secondary hypothesis. Columns 3, 7, and 11 show that before the beginning of the peace process in 2012, this relationship between deforestation and urban migration was even stronger. If deforestation increased by one percent, the average urban population would increase by 0.029%. This is an important observation for two reasons. First, this confirms the fact that Colombians fled from violence into urban centers and are now returning to their original land. Second, as stated by Albuja and Ceballos (2010), an increase in internally displaced peoples in urban centers leads to informal settlements, economic instability, and general inequality due to bureaucratic oversight (10). The rise in population density and subsequent rise in poverty levels greatly affects the carbon footprint of a large municipality, like Bogotá. Fortunately, as of recent, urban municipalities have started attempts to adapt to these climate and economic challenges.

For example, in 2019 Bogota improved transportation accessibility and reduced carbon emissions by building a solar-powered gondola (Moloney). Greener transportation helps increase economic participation in the IDP and migrant population that are forced to live in informal settlements or poor, under-resourced areas located outside of the urban center. Nevertheless, deforestation is related to rural flight and should therefore be considered in future policy decisions.

5.3 Potential Mechanisms

As stated earlier, economic factors like coca plantations and cattle ranches could explain the positive correlation between deforestation and migration. Unpredictable violence from the presence of armed groups, like the FARC, forced agricultural producers from their land. Therefore, when conflict began to resolve, small farmers and large corporations alike began to return to these lands and pursue profitable, in demand activities. Prem, Saavedra, and Vargas (2020) confirmed that deforestation increased in previously FARC-controlled municipalities, so for the sake of my research it was important to determine that these economic activities are not the main driving force behind the increase in migration. In order to test this empirically, I used the measures of coca plantations (hectares) and number of cattle livestock per hectare from Prem, Saavedra, and Vargas (2020).[9]

Table 3: Descriptive Statistics of Possible Mechanisms

Statistic	Mean	St. Dev.	Min	Median	Max
Number of Cattle Livestock per Hectare	38.182	36.176	0	29.7	213
Coca Plantations (in hectares)	0.0003	0.001	0	0	0

Table 3 Notes: This table presents summary statistics for the variables used to analyzed possible mechanisms. Each variable contains 16,288 observations that include data from 2002-2017 across 950 municipalities in Colombia.

Cattle ranching is not a labor-intensive activity while coca cultivation, like most agricultural production, can be. At the same time, cattle ranching is land intensive due to

[9] Prem, Saaverda, and Vargas (2020) use the 2014 national agricultural census to determine the number of cattle livestock.

extensive grazing (Prem et al. 2). Also, it is important to note that cattle ranching significantly contributes to an increase in carbon dioxide emissions. The environmental damage caused by these greenhouse gases are exacerbated by the removal of forest cover (Animal Production and Health Division 2). All factors considered; cattle ranches contain the power to influence the results of my study.

Table 4: Mechanism Regression Results - Cattle Ranches & Coca Plantations

	Dependent variable:					
	Number of Cattle per Hectare			Coca Plantations in Hectares		
	2002-2017	2002-2012	2013-2017	2002-2017	2002-2012	2013-2017
	(1)	(2)	(3)	(4)	(5)	(6)
Log of Deforestation	-0.014***	-0.013**	-0.021***	0.00001***	0.00002***	0.00001***
	(0.003)	(0.005)	(0.005)	(0.00000)	(0.00000)	(0.00000)
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16,288	11,198	5,090	16,288	11,198	5,090
R^2	0.915	0.915	0.915	0.969	0.969	0.969

Table 4 Notes: This table presents the regression results that investigate possible mechanisms of the positive relationship shown in *Table 2*. Both dependent variables were calculated using a logarithmic transformation. All regressions include municipality and time fixed effects. The years 2002-2012 refer to the period before the start of the peace process in 2012, while 2013-2017 represents the period after the peace process began. The data for the dependent variables - *Number of Cattle per Hectare* (Columns 1-3) and *Coca Plantations in Hectares* (Columns 4-6) – come from Prem, Saavedra, and Vargas (2020). The independent variable, Log of Deforestation, is derived from the GFC database (Hansen, et al. 2013) and represents the log of deforestation in square meters at the municipality level. Deforestation is calculated by a proportion of deforested area in a municipality in year t relative to the forest coverage of a municipality in 2000 (the first year provided by Hansen et al.). Controls added include index of state presence, distance to nearest military base, FARC presence in municipality or neighboring municipality, Tax Revenues, Poverty Index, and Coca suitability index. More information about the controls can be found in *Table 1*.
*p < 0:10; **p < 0:05; ***p < 0:01.

Table 4 displays the relationship between these respective mechanisms and deforestation. Across the board, cattle ranching and deforestation have a negative relationship (See Columns 1-

3). Concurrently, after the beginning of the peace process in 2012, this negative relationship became stronger (See Column 3).

Since this result is negative (Columns 1-3), cattle ranching is not the driving cause of migration. On the other hand, Columns 4-6 reveal that the number of coca plantations per hectare and deforestation have an exceedingly small, but positive, and highly significant relationship. Therefore, the increasing population results seen in *Table 2* are driven more by coca production rather than cattle ranching.

5.4 Heterogeneous Effects

One of the main purposes of this research design is to investigate the human cost of deforestation and its environmental consequences. Environmentally destructive economic practices, like deforestation, affect indigenous populations in an unproportionate manner. While it would be quite impossible to study the effects of deforestation on migration at an individual level of analysis, there are still ways to explore heterogeneous effects. In order to analyze this facet, I implemented a difference-in-differences design that compares departments with high indigenous populations with those that do not. By using data from the 2005 Census, "high indigenous population" in my research indicates that 22% to 61% of the department population belongs to an indigenous group. This includes Vaupés, Guiania, La Guajira, and Vichada. In order to quantitatively test the effect of deforestation on areas with high indigenous populations, I ran the following regression analysis:

Equation 2: Heterogeneous Effects Regression Equation

$$Population_{mt} = \alpha_{mt} + \beta_1 Deforestation_{mt} + \beta_2 Dummy\ indicator\ of\ high\ indigenous\ population_{mt} + \beta(Log\ of\ Deforestation \times Dummy\ indicator\ of\ high\ indigenous\ population)_{mt} + \delta_m + \lambda_t + X_{mt}\theta + \varepsilon_{mt}$$

Equation 2 builds on *Equation 1* with the addition of an interaction term. (*Log of Deforestation × Dummy Indicator of high indigenous population)*$_{mt}$ is the interaction term of interest between deforestation and indigenous populations. δ_{mt} and λ_{mt} respectively represent municipality and time fixed effects. . $X_{mt}\theta$ represents the same control variables as *Equation 1 (*described in *Section 4.3*).

The results shown below in *Table 5*, portray an interesting phenomenon. The coefficient on the interaction term suggests that deforestation had a *negative* impact on population changes in the urban centers of municipalities with a high concentration of indigenous population, thus creating a result that challenges our earlier analysis on rural flight. It appears that departments with high indigenous populations experience an increase in population in rural areas that includes people relocating from urban centers.

This is quite interesting considering it is the opposite effect than what is found in Columns 5-8 in *Table 2.* Columns 7-9 of *Table 5* exhibit a significant, positive relationship between deforestation and rural populations within departments with high indigenous population density. This relationship is even stronger during the years of conflict (2002-2012). Column 8 indicates that a one percent increase in deforestation should result in a 0.079% increase in the mean of rural municipal population that fall within the departments that have a population containing roughly 22% to 61% of people belonging to an indigenous group. According to reports from organizations like the Food and Agriculture Organization (FAO) of the United Nations, "forests are more likely to be maintained in indigenous communities that have secure land titles" (Butler). This could imply that indigenous groups are relocating to rural areas to protect their native land. On the other hand, this result could confirm that people are still opting to move into rural areas to pursue economic interests that coincide with deforestation.

Table 5: Heterogeneous Effect - Indigenous Populations

	Log of Municipality Population								
		Total			Urban			Rural	
	2002-2017	2002-2012	2013-2017	2002-2017	2002-2012	2013-2017	2002-2017	2002-2012	2013-2017
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log of Deforestation	0.018***	0.024***	0.014***	0.028***	0.046***	0.024***	0.007***	0.005***	0.006***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.003)	(0.002)	(0.001)	(0.002)	(0.002)
High Indigenous Population Dummy Indicator	0.463***	0.393***	0.446***	1.431***	1.867***	1.334***	-0.369***	-0.855***	-0.299***
	(0.042)	(0.067)	(0.064)	(0.056)	(0.091)	(0.087)	(0.045)	(0.071)	(0.067)
Interaction Term of Deforestation and High Indigenous Population	-0.010***	-0.005	-0.008	-0.064***	-0.096***	-0.059***	0.037***	0.074***	0.036***
	(0.003)	(0.005)	(0.005)	(0.004)	(0.007)	(0.007)	(0.003)	(0.005)	(0.005)
Total Interaction Effect	0.008	0.019	0.006	-0.036	-0.05	-0.035	0.044	0.079	0.042
Standard Error	(0.003)	(0.005)	(0.005)	(0.004)	(0.007)	(0.007)	(0.003)	(0.005)	(0.005)
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16,288	11,198	5,090	16,288	11,198	5,090	16,288	11,198	5,090
R^2	0.978	0.979	0.981	0.979	0.980	0.980	0.959	0.963	0.967

Table 5 Notes: This table presents the regression results that investigate the heterogeneous effect of deforestation and migration on areas with high indigenous population density. By using data from the 2005 Census, "high indigenous population" indicates that 22% to 61% of the department population belongs to an indigenous group. This includes Vaupés, Guiania, La Guajira, and Vichada. The years 2002-2012 refer to the period before the start of the peace process in 2012, while 2013-2017 represents the period after the peace process began. The outcome variable is the log of population (Total, Urban, and Rural are all within the same municipality). The independent variable, Log of Deforestation, is derived from the GFC database (Hansen, et al. 2013) and represents the log of deforestation in square meters at the municipality level. Deforestation is calculated by a proportion of deforested area in a municipality in year t relative to the forest coverage of a municipality in 2000 (the first year provided by Hansen et al.). Controls added include index of state presence, distance to nearest military base, FARC presence in municipality or neighboring municipality, Tax Revenues, Poverty Index, and Coca suitability index.
*p < 0:10; **p < 0:05; ***p < 0:01

5.5 Differential Effects in Municipalities with High Deforestation

Although the regression equations control for municipality fixed effects, municipalities in Colombia are still vastly different. For example, some municipalities could be predominantly urban and therefore do not contain enough forest coverage to be deforested. However, these municipalities are often the receptors of migrant populations.

Table 6: Marginal Effects Regression Results

	Log of Population					
	Total		Urban		Rural	
	(1)	(2)	(3)	(4)	(5)	(6)
Log of Deforestation	0.009^{***}	-0.004	0.016^{***}	0.014^{***}	-0.011^{***}	-0.028^{***}
	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.004)
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,141	4,070	8,141	4,070	8,141	4,070
R^2	0.986	0.995	0.987	0.995	0.968	0.981

Table 6 Notes: This table presents the main regression results applied to two subsets of the data in order to investigate marginal effects. The first subset (columns 1, 3, 5) includes all data points where total deforestation for one year is greater than the median of all the data or 413,100 square miles per municipality. The second subset (columns 2, 4, 6) includes data points from the 75th percentile, or third quartile. This group had a yearly deforestation total that was greater than 1,510,200 square miles. All regressions include municipality and time fixed effects over the time period 2002-2017. The outcome variable is the log of population (Total, Urban, and Rural are all within the same municipality). The independent variable, Log of Deforestation, is derived from the GFC database (Hansen, et al. 2013) and represents the log of deforestation in square meters at the municipality level. Deforestation is calculated by a proportion of deforested area in a municipality in year t relative to the forest coverage of a municipality in 2000 (the first year provided by Hansen et al.). Controls added to the original regression include index of state presence, distance to nearest military base, FARC presence in municipality or neighboring municipality, Tax Revenues, Poverty Index, and Coca suitability index.
*p < 0:10; **p < 0:05; ***p < 0:01.

In order to investigate these complexities, I ran a difference-in-differences design on marginal subsets of the data. The first subset group (Columns 1, 3, 5) includes all data points where total deforestation for one year is greater than the median of all the data or 413,100 square miles per municipality. The second subset group (Columns 2, 4, 6) includes data points from the 75th percentile, or third quartile. This group had a yearly deforestation total that was greater than 1,510,200 square miles. As we can see in *Table 5*, the regression results differ slightly from the original regression applied to that dataset as a whole. While *Table 2* and *Table 5* show a positive relationship between rural population and deforestation levels, this relationship appears to be the opposite when the comparison of municipalities includes only those with high levels of deforestation. This result challenges the notion that migrants are flowing into rural areas and seizing the economic opportunities that arise from deforestation. When deforestation increases by one percent in areas with the highest levels of deforestation (greater than 1,510,200 square miles), the rural population decreases by 0.028%. This -0.028% represents out-migration. Since the urban population increases by 0.014% in the same subset of municipalities, we can infer that rural populations are participating in rural flight and relocating to urban centers. There are a few explanations for this negative relationship. My original hypothesis is rooted in the idea that an increase in deforestation would lead to an increase in out-migration (decrease in population) because deforestation contributes to adverse climate change effects. While this could be the case, deforestation also influences the economic landscape. When large corporations or illegal economic actors enter the market, the purchasing power required to own or rent land increases significantly. This ostracizes the average person and forces them to either relocate or seek opportunity in the illicit production sphere. As stated earlier, Colombia is no stranger to the struggle for land equity. Overall, this paper affirms the notion that deforestation and migration are related. However, as we can see through analyzing specific municipality characteristics, we can see that this relation is quite complex and vulnerable to change, especially in the long run.

6. Conclusion

This paper focuses on the relationship between deforestation and migration at the municipal level in Colombia. My theoretical argument highlights that deforestation increases the adverse effects of climate change while also creating economic opportunities. This duality of deforestation can affect the movement of people in varying ways. My results suggest that when deforestation levels increase, the population of a municipality will grow as well. This is specifically evident in urban centers due to the phenomenon of rural flight.

My research is not perfect by any means and suffers greatly from the limits of time. Both Prem, Saavedra, and Vargas (2020) and Clerci et al. (2020) concluded that deforestation is increasing in the post-conflict Colombian context, yet the peace process did not conclude until 2016. The government is still seeking restitution for its people that suffered from the 50-year conflict. Peace between the Colombian government and the FARC does not imply that Colombia is now free from illegal armed-groups. Also, to reiterate, the economic practices mentioned throughout my theory provide short-lived success, especially with the combined influences of political instability and environmental deterioration. We are left with the following question: How will Colombia and other Amazon states break the volatile and vicious cycle of poverty, violence, and environmental destruction?

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