Forest cover changes and public policy: A literature review for post-conflict Colombia

Abstract

Tackling deforestation remains a significant challenge in tropical countries and even more so in those affected by armed conflicts. This is partly because of the limited local understanding of the causes of forest cover changes (FCC) and how these causes relate to development. In this study, we use Colombia as a model to contribute to the understanding of the links between the causes of FCC in conflict-affected countries and policies aimed at achieving sustainable development by targeting the agriculture, forestry and other land use (AFOLU) sectors. Specifically, we reviewed studies reporting on causes of FCC from 1995 to 2019 to build a state-of-the-art review. We then identified relevant public policies targeting AFOLU sectors and used them as a proxy for development. Finally, we discussed the links between these public policies and FCC. From the reviewed literature, it is clear that research on FCC in Colombia has focused on understanding the causes of forest cover losses while disregarding forest cover gains. Although cattle ranching and agriculture dominate the literature as proximate causes of deforestation and policy and institutional factors as underlying causes of deforestation, the relative importance of proximate and underlying causes of FCC in Colombia has changed over time. The main categories of policies that have been linked to FCC deal with conflict and post-conflict issues, coca eradication and, more recently, the implementation of the peace agreement. Another set of policies frequently mentioned are those related to productive activities. In Colombia, these policies' effects on forests will depend on how the state will regulate extractive activities in a post-conflict scenario. Therefore, it is imperative to review and update policies to tackle FCC, mainly deforestation, to successfully achieve sustainability targets in Colombia.

Keywords: deforestation, public policy, peacebuilding, post-conflict, drivers, Colombia.

Introduction

Despite decades of policies and economic instruments targeting the agriculture, forestry and other land use (AFOLU) sector worldwide, countries have more than fallen short on meeting their international environmental commitments, particularly those relating to deforestation (Harris *et al.* 2012, Zarin 2012, Nepstad, Boyd, *et al.* 2013, Redford *et al.* 2013, Seymour and Harris 2019). Several nations have set ambitious targets for halting deforestation under different international agreements, such as the Paris Agreement (United Nations 2015) and the Aichi Targets (Convention on Biological Diversity 2011). Nonetheless, tackling deforestation remains a significant challenge in tropical countries (Seymour and Harris 2019) and even more so in those affected by armed conflicts. This is the case for Colombia, which

is emerging from a long period of violence and has seen little to no government presence in most of its forested areas (Castro-Nunez 2018).

Several policy approaches have been promoted worldwide to influence the AFOLU sector (Pfaff *et al.* 2010). Some of these policies emerged with specific forest conservation objectives, such as those oriented toward the delimitation of "natural protected areas" for forest and biodiversity conservation, while others were conceived as development strategies to contribute to economic growth, such as those targeting the development of the agricultural sector and expansion of the agricultural frontier. The contribution of such policies to sustainable development, however, remains debatable, particularly considering that global tree cover loss has nearly doubled over the past 18 years (New York Declaration on Forests 2019).

These policies on forest cover loss have fallen short of their desired outcomes because the drivers of FCC are diverse, complex and often inextricable. These drivers span biophysical, socio-economic, institutional, environmental and cultural factors, and they interact across local, national and international scales (Lambin *et al.* 2001, Verburg *et al.* 2013). Determining the causes of FCC requires considering land-use dynamics, the agents who carry out forest clearing and the underlying causes that influence land-use decisions. These underlying causes might be linked to agricultural technologies, agroecological conditions, market prices, weak governance, the prioritization of economic development over environmental goals and the economic dependence of tropical countries on natural resources (agriculture, mineral extraction and timber). In conflict-affected countries, such as Colombia, policies aimed at achieving peace, along with the use of forests by armed groups in their military strategies, also influence FCC (Castro-Nunez *et al.* 2016, Castro-Nunez, Mertz, and Sosa 2017, Castro-Nunez, Mertz, Buritica, *et al.* 2017, Krause 2020).

Although conflict affects a significant number of tropical countries, globally promoted efforts to reduce deforestation do not necessarily consider contextual factors related to conflict and post-conflict settings, such as those relating to sustainable development and peace priorities. This is partly because such contextual factors are not yet fully understood and partly because these promoted forest conservation efforts were developed on the basis of global trends without consideration of specific conditions in regions and countries (Blom *et al.* 2010). Understanding the local causes of deforestation, therefore, is the first step toward framing realistic policies and innovative conservation solutions (Davidar *et al.* 2007). Furthermore, understanding the link between (a) policies integrating sustainable development and peace and (b) the causes of forest cover changes is key to the success of efforts to reduce deforestation (Wehkamp *et al.* 2018).

An example of these globally promoted strategies is the mechanism for reducing emissions from deforestation and forest degradation in the tropics, otherwise known as REDD+, which has been promoted by the UNFCCC since 2007 as a viable and cost-effective solution to mitigate climate change (Streck and Parker 2012). Assessments targeted deforestation related to land uses with low opportunity costs, such as subsistence agriculture (McCarthy and Tacconi 2011), while disregarding how the social and political contexts that prevail in fragile states would affect both viability and cost-effectiveness (Unruh 2011, Karsenty and Ongolo 2012). More recently, zero-deforestation supply chain interventions have taken center-stage as a promising alternative to reducing deforestation related to the production of agricultural commodities (Lambin *et al.* 2018). Thus far, there has been little evidence that REDD+ has globally reduced degradation of forests across the world (Duchelle *et al.* 2018, Krause 2020). Furthermore, it is not yet clear how effective this approach will be in contexts where the production of agricultural commodities are part of a wider peacebuilding strategy (Castro-Nunez *et al.* 2020). This suggests that defining and implementing effective national policies to halt deforestation requires an improved understanding of the causes of FCC and how they relate to sustainable development and peace priorities, particularly in countries emerging from conflict.

Using Colombia as a case study, this research contributes to understanding the link between the causes of FCC in conflict-affected countries and policies aimed at achieving sustainable development by targeting the AFOLU sector. We selected Colombia for the case study because it has experienced an alarming rise in deforestation rates in recent years, which recent studies have linked to sustainable development and peacebuilding policies (Baptiste *et al.* 2017, Negret *et al.* 2017, Landholm *et al.* 2019), such as the 2016 peace treaty between the government of Colombia and the Revolutionary Armed Forces of Colombia (FARC). Most of these studies were developed with the double objective of understanding the effects of the peace agreement on deforestation and informing policy formulation. These studies presented novel methodological approaches that suggested both negative and positive associations between conflict indicators and deforestation (Landholm *et al.* 2019, Negret *et al.* 2019). Nonetheless, they often fail to discuss their results in light of findings on what drives deforestation in Colombia. Meanwhile, the identification of direct and indirect drivers of FCC and understanding the complexity of their interlinkages are often difficult. This article contributes to increasing the knowledge about this subject by becoming the first attempt to systematically review and analyze the literature on the causes of forest cover changes in Colombia. More specifically, we determined the proximate and underlying causes of forest cover changes in Colombia by developing a systematic review of the scientific literature on the drivers of FCC in Colombia. In the following section, we present examples of economic and policy instruments that have targeted the AFOLU sector in Colombia. We present the methods for and results of our review in

sections 3 and 4, respectively. Lastly, we discuss a) the proximate and underlying causes of FCC in Colombia and whether there are understudied areas within the research on FCC drivers in Colombia; b) how the understanding of the causes of FCC in Colombia has changed in the literature over time; and c) how public policies aimed at achieving development priorities targeting the AFOLU sector are linked to FCC in Colombia.

Economic and policy instruments targeting the AFOLU sector in Colombia

The conflict between guerrilla and paramilitary groups and the government in Colombia lasted for over five decades. The armed conflict has internally displaced more than 7 million people (Negret *et al.* 2017) mostly from rural to urban regions. Illicit coca production has greatly financed the activities of these guerrilla and paramilitary groups (Álvarez 2007, Sánchez-Cuervo and Aide 2013). Guerrillas and paramilitaries carried out this illegal activity in large forested lands with weak state presence (Sánchez-Cuervo and Aide 2013). In November 2016, the Colombian government and FARC, one of the biggest and oldest guerrilla groups in Colombia, signed a peace agreement.

Despite decades of economic and policy instruments targeting the AFOLU sector in Colombia (see Table 1), an average of 1.5 million ha was deforested between 2005 and 2015 (González *et al.* 2018). While some of these policies directly target forest conservation and natural resource management, many of them mainly aim to achieve economic and rural development. Generally, policies targeting the AFOLU sector have been related to 1) conflict and post-conflict issues; 2) promotion of production activities; 3) land tenure and territorial zoning; and 4) conservation and sustainable management of forests and natural resources.

Table 1. Timeline of the most representative policies targeting the AFOLU sector in Colombia. Policy categories: (1) conflict and post-conflict; (2) promotion of productive activities; (3) land tenure and territorial zoning; (4) conservation and sustainable management of forest and natural resources.

Timeline of the most representative policies targeting the AFOLU sector in Colombia			
Date	Policy Instrument	Specific Target	Policy Category
1959	Law 2	Protective Forest Areas and General Interest Forests	3
1974	Law 2811	Protective Forest Areas and General Interest Forests	3
1974	Decree law 2811	Logging permits	4
1993	Law 99 article 111	Forest harvesting regimes	4
1994	Law 160	Land distribution mechanisms	3

1995	Decree 2164	Indigenous reserves	3
1995	Decree 1745	Lands of Afro-Colombian Communities	3
1996	Decree 1777	Campesina reserve zones	3
1996	Decree Law 1791	Decentralization of management	3
1997	Decree 900	Incentives for conservation/reforestation	4
2001	Law 685	Promotion of mining	2
2001	CONPES 3125	National forest development plan	4
1999 - 2002	//	Failed peace process	1
2003	CONPES 3218	Alternative development to eradicate illicit crops	1
2003	Decree law 812	Tax discount for reforestation	4
2004	Law 939	Production and commercialization of biofuels	2
2005	Decree 1970	Regulates the law 939 on biofuels	2
2005	Law 99 (1993) regulated by 1220	Environmental licenses	4
2007	Decree law 1151	Assigns MADS the responsibility of developing Payments for Ecosystem Services system (PES)	4
2008	CONPES 3527	National policy for competitiveness and productivity	2
2008	CONPES 3510	Promote sustainable biofuel production	2
2010	CONPES 3669	Manually eradicate illicit crops	1
2011	Law 1448	Land restitution	1
2011	Law 1454	Territorial zoning	3
2011	Law 1450 article 195	Territorial consolidation and reconstruction	1
2013	ENREDD	National REDD+ Strategy	4
2013	CONPES 3762	Projects of national and strategic interest	2
2015	CONPES 3850	Colombia in peace fund	1
2016	Vision Amazonia	Reduce deforestation and carbon emissions	4
2017	TFA Colombia	Zero deforestation value chains	4
2017	Decree 902	Comprehensive Rural Reform (Reforma Rural Integral):	1

		• Development Programs with Territorial Approach (PDET) • Property rights • New agricultural census and cadaster	
2017	Decree 870	PES system	4
2018	Law 1931	Climate change management	4

Policies related to conflict and post-conflict have mostly focused on the eradication of illicit crops and the development of alternative economic activities (Departamento Nacional de Planeación 2003, 2010). They have also targeted land restitution and reparations for victims of the armed conflict. Colombia's Victims and Land Restitution Law of 2011 was one of the first laws in South America to make reparations to victims of an ongoing conflict (Forero-Nino 2012); under this statute, the nation is striving to compensate or resettle some of the 5–6 million farmers displaced from their land during the conflict (Nepstad, Boyd, *et al.* 2013). After the peace agreement was signed, focus was directed towards implementing the Comprehensive Rural Reform and the tools to achieve this reform (e.g., PDET).

Meanwhile, policies targeting production-related activities have mostly focused on increasing the competitiveness of different sectors. The National Policy for Competitiveness and Productivity (Departamento Nacional de Planeación 2008), for instance, included an action plan for the competitiveness of the agricultural sector. This plan detailed actions to improve land use, increase the efficiency of agricultural production chains and achieve sustainability as a factor of competitiveness, among others. It also included actions for formalizing land tenure.

Policies related to land tenure and territorial zoning have included directives to transfer forest management authority to local governments or communities. For example, Decree 1791 (1996) established a forest harvesting regime and granted regional autonomous corporations the authority to manage forest resources within their jurisdictions (de la Torre *et al.* 2011). Also included in this group of policies is Law 160 (1994), which introduced a market-assisted land reform program (Grusczynski and Jaramillo 2002) and stipulated that unoccupied government lands could be granted to farmers who have no land to cultivate as long as two-thirds of the land is used for economic purposes (Article 8).

Among the policies related to conservation and sustainable management of forests and natural resources, Law 2 (1959) and Decree Law 2811 (1974) defined special management areas, such as those for the administration, management and protection of the environment and renewable natural resources. This group of policies also includes permits for the sustainable use of forest resources, such as the Forest Law

(1996), which defined forest-use regimes and regulates the activities of individuals and public administrations with respect to the use, management, exploitation and conservation of forest resources. Likewise, economic incentives have been used to increase the value of standing forests and promote sustainable production alternatives, such as the creation of a PES system through Decree 1151 (2007) and Decree 870 (2017a).

More recently, Colombia adopted a comprehensive set of ambitious policies and programs in order to achieve its commitment of reaching zero net deforestation in the Colombian Amazon by 2020 (Mendoza *et al.* 2017). These policies include the national REDD+ strategy and others oriented toward sustainable land use, the expansion of protected forest areas and the development of zero-deforestation agricultural supply chains. For example, Visión Amazonía 2020 was designed as a policy instrument to carry out the national REDD+ strategy through a sustainable development model. The initiative aims to reduce emissions from deforestation by establishing incentives for communities and sectors to sustainably manage forests and improve natural resource use. The "Governance for Conservation and Sustainability at the Heart of the Colombian Amazon" program seeks to conserve and sustainably manage more than 11 million ha of forest by consolidating protected areas and indigenous territories in the Amazon so as to restrict the expansion of the agricultural frontier (Nepstad, Irawan, *et al.* 2013). In 2017, Colombia joined the Tropical Forest Alliance, a platform committed to eliminating deforestation along the supply chains of several agricultural products (Tropical Forest Alliance 2020 2017). Through this initiative, public and private institutions are developing sustainable value chains of cocoa, palm oil, wood, fish farming, milk and meat cattle, among others (Tropical Forest Alliance 2020 2017), together with the support of the national government. Policy initiatives under Visión Amazonía 2020 also target developing zero-deforestation supply chains.

Methods

Systematic review

We conducted a systematic review to identify the main causes of deforestation in Colombia as reported in the literature. A quick search yield that the first article was published in 1995. Therefore, we started by searching for peer-reviewed articles published from 1995 to 2019 within the Web of Science™ database and narrowed the search on the basis of the title, keyword or abstract of each article. We searched using the Spanish and English version of the words deforestation and/or land use change and/or landscape change and/or land cover change and/or forest cover change; and illicit crops and/or cattle ranching and/or biofuels and/or agriculture and/or infrastructure and/or conflict and/or illegal logging and/or

mining; and Colombia[1,2]. We reviewed the titles of the resulting 185 articles to ensure that the documents were related to the main topic of the search. This process yielded 168 selected articles, which we placed in a preliminary database. We then reviewed the abstracts of the articles in that database to ensure they included information on (1) deforestation or forest degradation caused by any activity that results in changes in forest cover and/or (2) the causes of changes in forest cover. We deleted articles that did not comply with the selection criteria. After this process, we had 84 documents that we put into a second database. We fully reviewed the articles from the second database and collected information pertaining to the causes of deforestation and associated public policies. After further analysis, we removed articles that did not present the required information. We added three additional papers that the authors knew of but did not show up during the systematic review[3], for a total of 68 papers included for the analysis (see Figure 1).

Data analysis

We conducted a quantitative analysis of the information collected through the literature review by identifying first the proximate causes and then the underlying causes of changes in forest cover.

[1] The exact clause used in English was (1) TS=(deforest*) OR TS=(land NEAR/5 use NEAR/5 change*) OR TS=(landscape NEAR/5 change*) OR TS=(land NEAR/5 cover NEAR/5 change*) OR TS=(forest* NEAR/5 cover NEAR/5 change*) AND TS=(ill* NEAR/5 crops) OR TS=(cattle NEAR/5 ranch*) OR TS=(biofuel*) OR TS=(agricult*) OR TS=(infrastructure*) OR TS=(conflict*) OR TS=(ill* NEAR/5 log*) OR TS=(mining); (2) TS=(clause#1 AND Colombia) AND Timespan=1995-2019

[2] The exact clause used in Spanish was (1) TS=(deforest*) OR TS=(cambio NEAR/5 uso NEAR/5 suelo) OR TS=(cambio NEAR/5 paisaje) OR TS=(cambio NEAR/5 cobertura NEAR/5 suelo) OR TS=(cambio NEA R/5 cobertura NEAR/5 bosque) AND TS=(cultivo* NEAR/5 ilicito*) OR TS=(ganaderia) OR TS=(bioco mbustible*) OR TS=(agricultura) OR TS=(infraestructura) OR TS=(conflicto*) OR TS=(tala NEAR/5 ile gal) OR TS=(mineria); (2) TS=clause#1 AND Colombia) AND Timespan=1995-2019

[3] While these articles met the inclusion requirements established by the researchers, they were not yielded in the WoS search possibly because at the time of the search this database did not have the rights to the articles. Due to the relevance of each article, the research team opted to include them in the analysis.

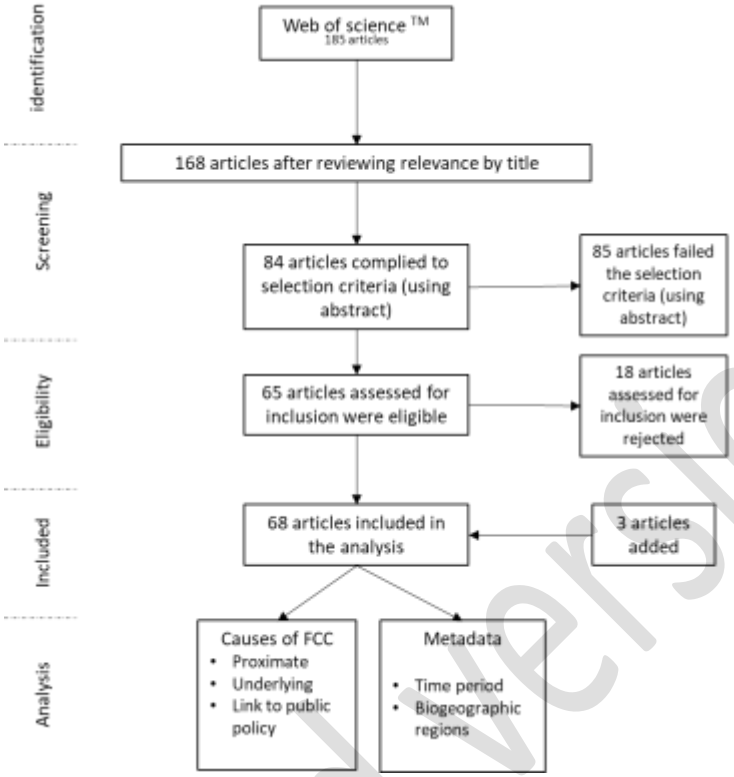


Figure 1. Methodological scheme presenting the selection process of publications for this review.

Coding of proximate causes

Geist and Lambin (2002) define proximate causes as human actions related to land use that impact the forest cover directly. For the coding of proximate causes, we adapted to the local context the three categories (infrastructure, agriculture and wood extraction) that Geist and Lambin (2002) propose. This step generated six categories: (1) *agriculture*, which includes large- and small-scale agriculture, biofuel crops (e.g., palm oil) and the agricultural frontier; (2) *livestock*, which falls under the category of agriculture per Geist and Lambin (2002) but is examined separately for the Colombian context because livestock occupies the majority of land suited for agriculture in the country, and cattle ranching represents the second most extensive land use in terms of area after forests, according to the Unidad de Planificación Rural Agropecuaria (UPRA); (3) *illicit crops*, whose cultivation we viewed separately from agriculture for the history of the country's conflict and the role of this crop in financing some of the armed groups in conflict; (4) *infrastructure;* (5) *wood extraction*; and (6) *fires*, which Geist and Lambin (2002) considered to be among "other factors."

Coding of underlying causes

Geist and Lambin (2002) define underlying causes as social processes that influence decision-making related to land uses. Their impact on forest cover, hence, is indirect. For the coding of underlying causes, we adapted to the local context the five categories that Geist and Lambin (2002) proposed. This resulted

in the following categories: (1) *socio-economic factors,* which cover issues related to poverty and communication access; (2) *demographic factors,* which principally include population growth and density and also consider migration not caused by the armed conflict; (3) *conflict factors*, which span all aspects related to the armed conflict in Colombia, including forced displacement; (4) *policy and institutional factors,* which encompass policies related to Colombian drug eradication and pacification, macroeconomic and development policies, and topics of land tenure and land acquisition; (5) *technological factors*, which comprise issues related to agricultural practices and productivity; and (6) *environmental factors,* which constitute environmental conditions, including biophysical drivers such as agroclimatic conditions.

Metadata of case studies

In addition to the information obtained on proximate and underlying causes, we recorded the date of each publication to explore research trends over time. We analyzed the collected information according to the following time periods: 1995–1999; 2000–2004; 2005–2009; 2010–2014; and 2015–2019. We also collected the biogeographic regions mentioned in the literature to identify possible differences between the regions of Colombia. These biogeographic regions constitute the Amazon, Andean, Caribbean, Orinoquia and Pacific. We also added a "national" region category to account for studies conducted and reported at the national level. Furthermore, we collected information on the number of studies at the local or national level (case studies) and identified whether or not the studies disclosed the size of the area under FCC.

Results

The 68 articles reviewed in this study reported causes of forest cover changes (FCC) from 111 case studies at national, regional and local levels. Studies carried out at the national scale account for the biggest share of the case studies reviewed (30%), followed by the Amazon region (22%), the Andean region (19%), the Orinoquía region (12%), the Caribbean region (12%) and 5% in the Pacific region (see Figure 2).The most reported FCC was deforestation (93% of case studies). Studies to a lesser extent have reported on forest regeneration (13% of case studies) and forest conservation (2% of case studies).

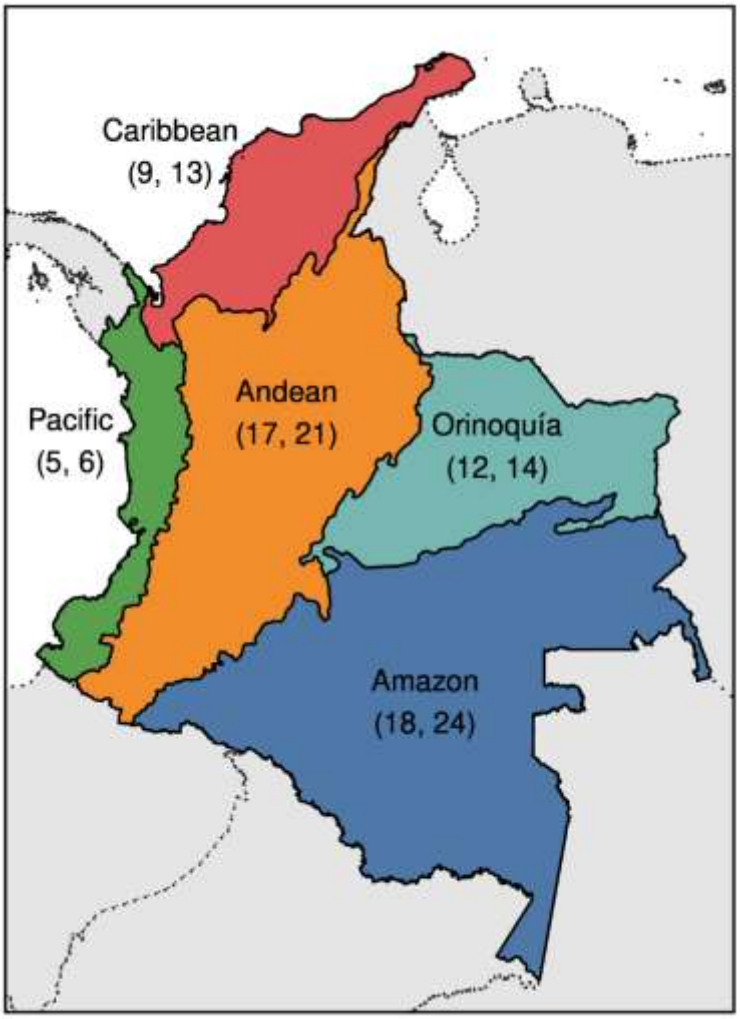


Figure 2. Map of the biogeographic regions in Colombia and the number of publications and case studies reported per region; national, 30 publications and 33 case studies.

Proximate causes of forest cover change in Colombia

We identified in the literature six proximate causes of FCC, mainly deforestation. As figure 3A shows, the most mentioned causes were cattle ranching (31%), agriculture (29%) and illicit crops (21%), followed by infrastructure and mining (14%), wood extraction (3%) and fires (2%). As expected, forest regeneration and forest conservation were not frequently linked to any of the six proximate causes mentioned above. From the studies that mentioned agriculture as a proximate cause of deforestation, 11%

explicitly cited agriculture for biofuel production and 10% identified the expansion of the colonization front, which was mainly in the Amazon region.

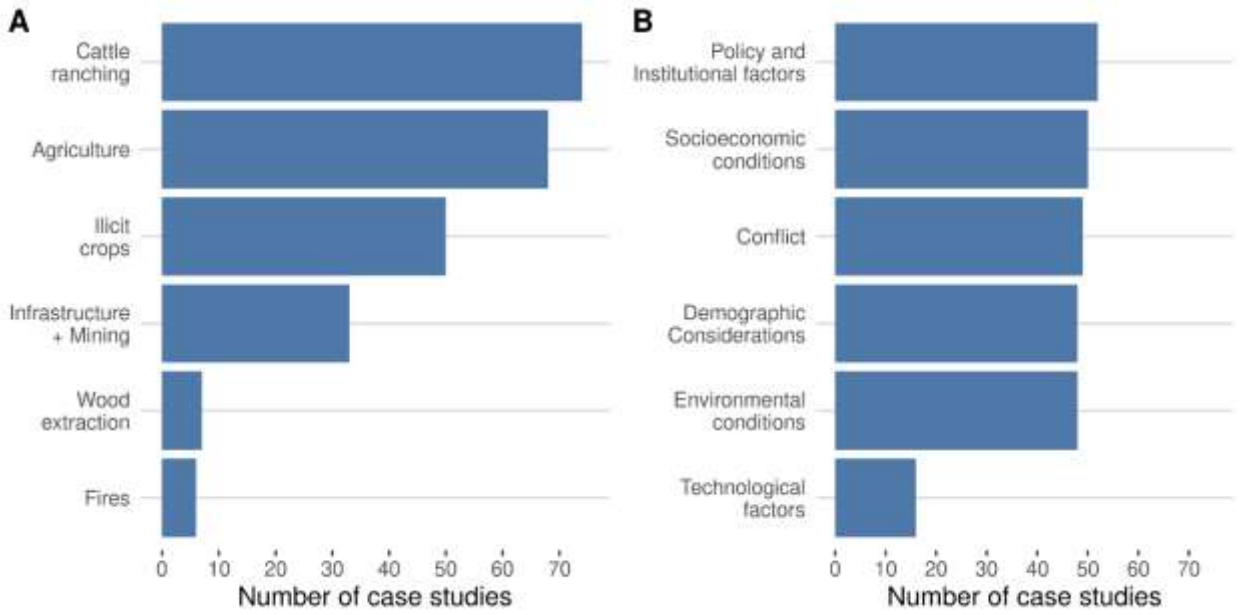
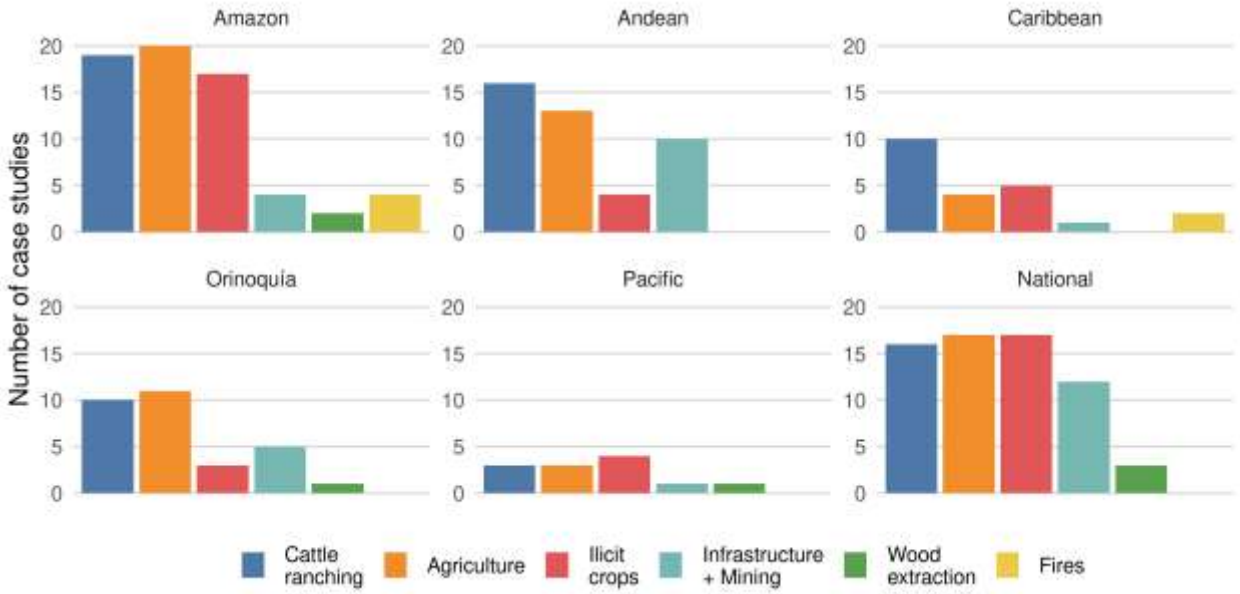


Figure 3. A: frequency of mention of proximate causes of FCC on case studies (studies carried out at the local or national level).
Figure 3. B: frequency of mention of underlying causes of FCC on case studies (studies carried out at the local or national level).

Figure 4 shows that the literature mentions cattle ranching and agriculture as the two main proximate causes of FCC in the Amazon, Andean and Orinoquia regions. In the Amazon, however, illicit crops are frequently mentioned as well. In the Pacific region, with the exception of fires, the proximate causes — cattle ranching, agriculture, illicit crops, infrastructure and mining and wood extraction — are equally mentioned. However, this region is also the least represented in the studies reviewed. Results also show that illicit crops, cattle ranching and agriculture are the three proximate causes of FCC most mentioned in studies carried out at the national scale.



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273 *Figure 4. Main proximate causes of FCC mentioned per biogeographical regions.*

Underlying causes of forest cover change in Colombia

Overall, case studies equally mention all the underlying causes except technological factors (Figure 3B). By only a marginal difference, policy and institutional factors were the most frequently mentioned underlying cause. It is important to note that from the 52 case studies that mentioned policy and institutional factors, 60% relate to land acquisition and land tenure, 46% relate to eradication and pacification policies and 44% relate to macroeconomic and development policies.

When looking at the data at the regional level, some noticeable differences emerge. Studies on the Amazon and Orinoquia regions identify demographic considerations as the main underlying cause. In the Amazon, however, socio-economic conditions also appear to be an important underlying cause. Studies on the Andean and Caribbean regions more commonly mention environmental factors as an underlying cause. Those on the Pacific region most commonly cite conflict and policy and institutional factors as underlying causes. None of the local- or national-level studies focused on this region identifies technological factors as an underlying cause of FCC. Studies carried out at the national scale, meanwhile, indicate policy and institutional factors and conflict as the two main underlying causes of FCC.

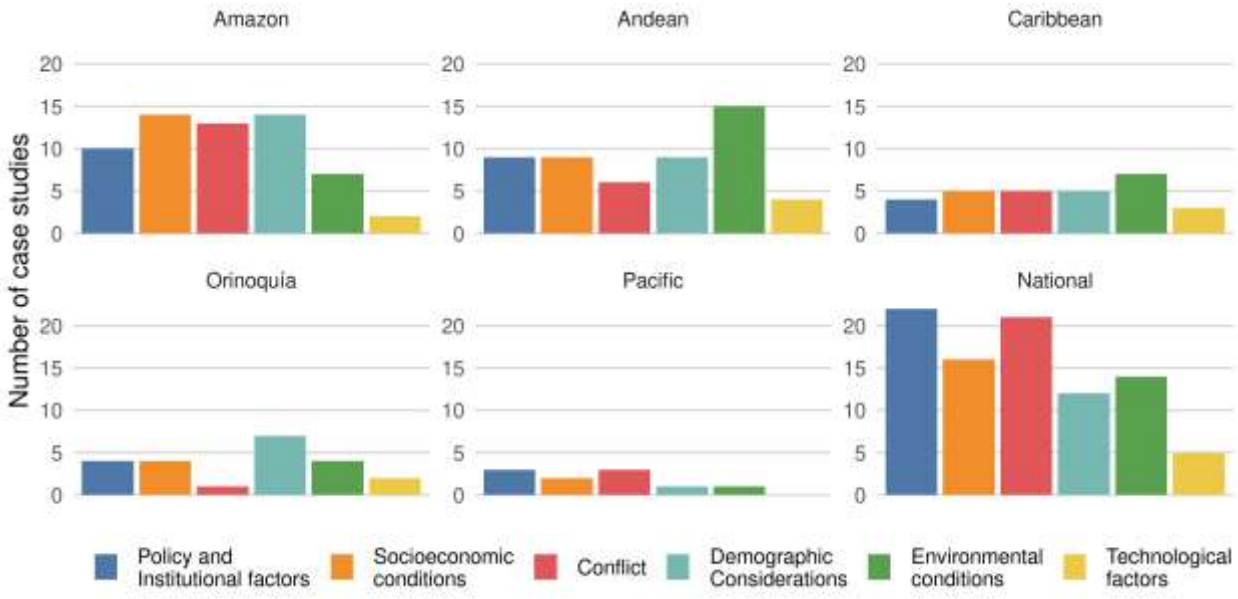

Figure 5. Main underlying causes mentioned per biogeographical region.

FCC in Colombia over time

As Figure 6A and 6B shows, over time, the number of proximate and underlying causes reported in the literature has been growing in parallel with the number of articles. Nowadays, it is more common to find articles that mention both types of causes and dive deeper into the understanding of FCC. The first article

included in the present review was published in 1995. Since then, an increasing interest in understanding the proximate and underlying causes of FCC in Colombia has been seen, with a maximum of 27 articles published in the period from 2015 to 2019.

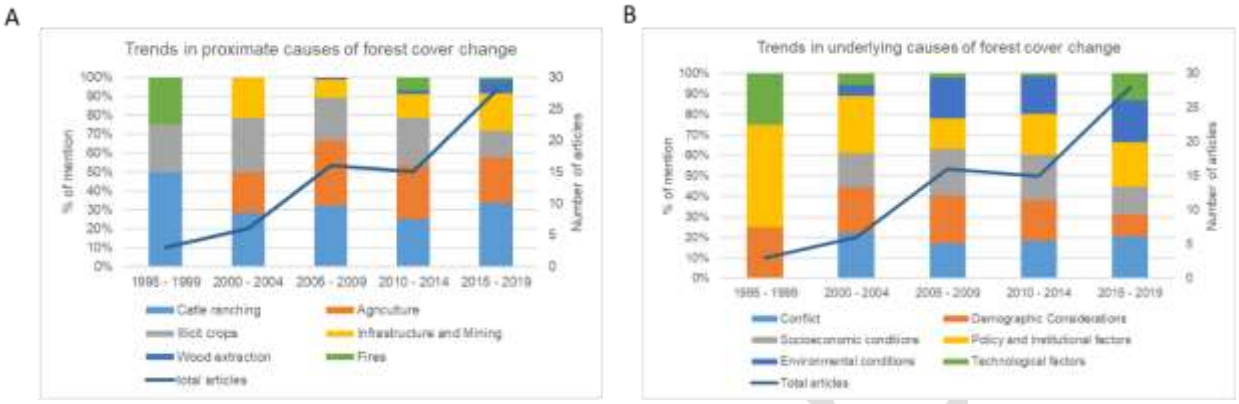

Figure 6.A: trends in proximate causes of FCC across five periods.
Figure 6.B: trends in underlying causes of FCC across five periods.

During the period of 1995–1999, the majority of the articles mentioned cattle ranching as the main proximate cause of forest cover change, followed by illicit crops and fires. Underlying causes such as policy and institutional factors, demographic considerations and technological factors accompanied these proximate causes. During 2000–2004, studies continued to mention cattle ranching and illicit crops as the main causes of FCC, but some (20% of articles) noted two additional proximate causes: agriculture and infrastructure. None mentioned fire as a proximate cause. Similarly, most studies during this period still mentioned policy and institutional factors as underlying causes, followed by demographic considerations and conflict. Some studies likewise mentioned socio-economic conditions, technological factors and environmental conditions as underlying factors.

During the period of 2005–2009, reviewed studies started to mention wood extraction and increasingly mentioned agriculture as proximate causes of deforestation. Cattle ranching and illicit crops continued to dominate as proximate causes, followed by infrastructure. The underlying causes most frequently mentioned were demographic considerations, socio-economic conditions and environmental conditions, followed by conflict and policy and institutional factors. Compared with the previous period of analysis, it seems that during 2005–2009, technological factors were less frequently mentioned.

Reviewed studies for the period 2010–2014 mentioned three proximate causes equally: agriculture, illicit crops and cattle ranching. Infrastructure and fires were mentioned in fewer cases, and only one article during this period mentioned wood extraction. The underlying causes seem to resemble the previous time

period (2005–2009), but with a small increase in the frequency of mention of policy and institutional factors and a decrease in the frequency of mention of demographic considerations.

Finally, during the period of 2015–2019, cattle ranching was again the most frequently mentioned proximate cause, followed by agriculture and infrastructure. Illicit crops were mentioned less frequently than in previous periods but were still regarded as an important cause. During this period, wood extraction became more frequently mentioned, and fire was mentioned only by one article. The most frequently mentioned underlying causes during this time were policy and institutional factors, environmental conditions and conflict. Technological factors started to be mentioned more frequently during this time than in previous periods. Socio-economic and demographic considerations were less frequently mentioned than in previous time periods.

Discussion

In the following sections, the results of the study are used to discuss the following: a) the proximate and underlying causes of FCC in Colombia and the understudied areas within the research on FCC drivers in Colombia; b) how the understanding of the causes of FCC in Colombia has changed in the literature over time; and c) how public policies targeting the AFOLU sector are linked to FCC in Colombia.

a) Proximate and underlying causes of FCC

Results indicate that the causes of FCC in Colombia have generally been debated and have varied across regions. The literature most frequently mentioned cattle ranching, agriculture and illicit crops as proximate causes, and political and institutional factors, socio-economic conditions and conflict as underlying causes of FCC in Colombia. According to the literature, the impacts of the proximate causes of FCC vary across Colombian regions (Armenteras *et al.* 2009, Armenteras, Rodríguez, *et al.* 2013, Sánchez-Cuervo and Aide 2013) according to certain factors: political, such as the presence of different armed groups; institutional, such as land use categories; socio-economic, demographic and biophysical (Armenteras *et al.* 2009, 2011, Sánchez-Cuervo and Aide 2013, Castro-Nunez, Mertz, and Sosa 2017). The reviewed studies also frequently mentioned population increase as an underlying cause. In that regard, Perz *et al.* (2005) showed a negative relationship between deforestation and migration to urban areas. Based on these results, the authors argue that deforestation in Colombia has little to do with population increase. This claim, however, contradicts what we found in the literature, where 44% of cases mentioned the relationship between deforestation and demographic factors. A considerable number of studies outside Colombia (e.g., Pfaff 1999) make the same argument as Perz *et al.* (2005). These studies suggest that even if demographic factors are related to deforestation, demographic factors are not acting alone in driving deforestation. This corresponds with the trends we identified: we did not find any case that attributes FCC to a single proximate or underlying cause.

Views differ on how forced displacement relates to FCC in Colombia. Firstly, some authors agree that forced displacement can lead to a decreased pressure on forests, therefore halting deforestation (Armenteras *et al.* 2011). However, other authors agree that after the signing of the peace treaty, displaced people may return to the countryside and therefore increase the pressure on forests (Sánchez-Cuervo and Aide 2013, Salazar *et al.* 2018). Secondly, other authors consider that forced displacement increases deforestation (Hoffmann *et al.* 2018) through two mechanisms: one, violent groups establish pastures as a way to secure and accumulate land, thus displacing people (Urrego-Mesa *et al.* 2018); and two, displaced people move further into the forest to continue growing illicit crops (Dávalos *et al.* 2016). Landholm *et al.* (2019) argue that depending on the region of analysis, the impact of forced displacement on forest cover can be positive or negative.

As mentioned before, various studies identified the conversion of forest areas to pastures for livestock as an important proximate cause of FCC — predominately deforestation — in Colombia (Vina and Cavelier 1999, Etter, McAlpine, Wilson, *et al.* 2006, Etter *et al.* 2008, Dávalos *et al.* 2011, 2014). Others identified agriculture as a proximate cause of current FCC (Etter *et al.* 2008, Murillo-Sandoval *et al.* 2018, Quintero-Gallego *et al.* 2018). Only a few studies, though, specifically mentioned the type of crop or

agriculture that generates the FCC (e.g., Boron *et al.* 2016). Attention is given to palm oil plantations (Romero-Ruiz *et al.* 2012, Boron *et al.* 2016, Ricaurte *et al.* 2017), especially when taking into account policies that have increased the area of palm oil production, such as Law 939 of 2004 and Decree 1970 of 2005 (Boron *et al.* 2016). Moreover, the literature highlights the possible risk that palm oil expansion will occur in areas of the colonization frontier (Castiblanco *et al.* 2013), which feature high forest cover.

Illicit crops were also frequently mentioned as a proximate cause of deforestation (Cavelier and Etter 1995, Álvarez 2002, Armenteras *et al.* 2006, Dávalos *et al.* 2011, Rincón-Ruiz *et al.* 2016, Suarez *et al.* 2018, Landholm *et al.* 2019). In this regard, it is important to note that the officially reported deforestation rate for Colombia — more than 300,000 ha/yr between 1990–2005 and around 120,000 ha/yr between 2005–2015 (González *et al.* 2018) — far exceeded the area planted with coca, which was approximately 169,000 ha in 2018 (UNODC and Gobierno Nacional de Colombia 2019). This would suggest a low relative impact on forest loss. It is, however, estimated that the area of coca associated with deforestation would be equivalent to 2.5–4 times the area planted due to food crops and airstrips used during the coca production process (Cavelier and Etter 1995, Álvarez 2007). This, therefore, positions illicit crops as an important proximate cause of deforestation. Although the national trend during 2001–2008 demonstrated a decline in coca leaf production (Rincón-Ruiz and Kallis 2013), this decrease was mainly concentrated in the Amazon and Orinoquia regions, where the planted area declined from 71,920 ha in 2001 to 22,270 ha in 2008. In the Pacific, Caribbean and Northern Andes, however, the area increased from approximately 2,000 ha in 2001 to about 8,500 ha in 2008 (Rincón-Ruiz and Kallis 2013). This trend suggests a displacement of coca leaf production from some regions of Colombia to others. Some studies argue that this leakage of coca production would have been explained by forced coca eradication policies (as promoted in the National Plan of Alternative Development - PLANTE). An instrument of these policies is the glyphosate aerial spraying program, which has also been associated with losses in forest cover. Specifically, scholars have considered this program a contributor to the displacement of illicit crop production (Rincón-Ruiz and Kallis 2013).

There was little mention of wood extraction and mining as proximate causes of FCC in the literature, with the latter even being related to low rates of deforestation (Hosonuma *et al.* 2012, Armenteras, Cabrera, *et al.* 2013). This is not to say that the impact in environmental terms that these activities generate is insignificant or that the potential for future impacts on FCC should be ignored. Rather, this could indicate difficulties in monitoring activities that in some cases are being carried out informally (Hoffmann *et al.* 2018).

This review revealed that deforestation has been the main form of FCC studied in Colombia, while forest regeneration has received little attention. The lack of information on this topic could indicate that

assessing forest regeneration in Colombia is difficult because many areas are under grassification. Known as *praderización* in Spanish, grassification refers to the change of forest cover to grazing land associated with cattle that is not used for productive purposes — a practice that hinders natural forest regeneration (González *et al.* 2018). Some articles, however, do report about forest regeneration, mostly in the Andean (Mendoza and Etter 2002, Sánchez-Cuervo *et al.* 2012) and Amazon regions (Etter, McAlpine, Pullar, *et al.* 2006). The regeneration reported appears to be linked with rotation practices (Vina and Cavelier 1999, Rodríguez *et al.* 2013). Other authors link regeneration with reforestation programs (Mendoza and Etter 2002) and with projects related to the protection of hydrographic basins (Sánchez-Cuervo *et al.* 2012).

Another understudied topic is mining. It is important to remain attentive to the potential impacts of mining activities on FCC due to the increasing interest of the Colombian government in this sector: the government sees this sector as an economic motor (Suarez *et al.* 2018). Regarding the biogeographic regions of Colombia, the Pacific region was the least studied region in the literature on FCC. This is surprising because 79% of the region is covered by forest (González *et al.* 2018). It is also important to note that the mining activity in Quibdo, the biggest municipality in the Pacific region, represented 18% of its GDP from 2000 to 2013 (González *et al.* 2018).

b) Evolution in the understanding of FCC in Colombia

Trends in the reporting of proximate causes of FCC in Colombia demonstrate that the topic started to become more complex as the literature shifted from identifying three main proximate causes in 1995–1999 to six in 2015–2019. Cattle ranching was the main cause mentioned in studies during the 1990s. From 2000 onwards, studies continued to mention cattle ranching but also cited other proximate causes that appeared to be as important as cattle ranching, such as agriculture as well as infrastructure and mining.

Regarding the underlying causes, it is clear that the complexity of the topic also has been increasing over time. Policy and institutional factors were the main underlying causes presented in the studies carried out in 1995–1999. Although this continues to be the case in more recent studies (2015–2019), conflict, environmental considerations and technological factors started gaining importance during this later time.

Examining the interactions between cattle ranching, illicit crops and land acquisition provides a glimpse into how the understanding of FCC drivers in Colombia has evolved. Early studies reported that interactions between illicit crops and cattle pastures characterized colonization in Colombia because the expansion of new agricultural colonization fronts, in some cases, followed the production of illicit crops, which then resulted in the establishment of large tracts of pasture for livestock (Viña *et al.* 2004, Etter *et al.* 2005, Dávalos *et al.* 2009, Van Ausdal 2009, Chadid *et al.* 2015). These studies suggest that livestock

and illicit crops play differentiated roles in colonization processes, which accessibility factors would determine. In this way, the changes in forest cover attributed to illicit crops are mainly related to the opening of new colonization fronts, while deforestation caused by cattle pastures is related to the expansion of the agricultural border and consolidation of urban areas (Chadid *et al.* 2015). Cattle ranching has been historically mentioned as a major cause of FCC (Viña *et al.* 2004, Van Ausdal 2009, Chadid *et al.* 2015). Recent literature (e.g., Castro-Nunez, Mertz, Buritica, *et al.* 2017, Gutiérrez-Sanín and Vargas 2017), however, indicates that cattle ranching is identified as a tool to grab land in Colombia. Specifically, empirical results suggest that economic factors do not influence livestock production and beef production as much as factors related to territory control, land acquisition and grabbing (Yepes 2001, Dávalos *et al.* 2014, Castro-Nunez, Mertz, Buritica, *et al.* 2017)

Since 2017, several articles have started to explore the link between the peace agreement in Colombia and its impact on FCC, mainly in terms of deforestation. A few articles have already reported an increase in FCC after the signing of the peace treaty (Salazar *et al.* 2018, Armenteras *et al.* 2019). Others have pointed out that new deforestation drivers could emerge if the government does not prioritize conservation when implementing the peace agreement (Calle-Rendón *et al.* 2018, Hoffmann *et al.* 2018, Salazar *et al.* 2018). Even though the peace negotiations included topics related to land management and development (Castro-Nunez, Mertz, and Sosa 2017, Salazar *et al.* 2018), there remains a degree of uncertainty over how the treaty will affect forest cover. Most of the articles, therefore, pinpoint strategies to avoid environmental impacts as a collateral consequence of the peace treaty. Some of the strategies mentioned include strengthening of environmental institutions (Suarez *et al.* 2018, Armenteras *et al.* 2019); the inclusion of local communities in defining land management and conservation programs (Calle-Rendón *et al.* 2018, Hoffmann *et al.* 2018, Armenteras *et al.* 2019); the promotion of forest-friendly land-use systems in the production of global commodities (Baptiste *et al.* 2017); the creation of new protected areas (Calle-Rendón *et al.* 2018); and the prioritization of development strategies in regions where forests are already cleared (Salazar *et al.* 2018). These strategies demonstrate the need to implement sound policies that align with peacebuilding priorities and environmental factors (Castro-Nunez, Mertz, and Sosa 2017).

Lastly, due to the scope of this review and the search engine used in our methodology, few Spanish-written publications met our search criteria. Future research should attempt different approaches to incorporate a systematic review of the Spanish literature as Colombia has a significant academic tradition that links the formation of national parks and collective land rights to FCC.

c) Links between forest cover changes and policies targeting the AFOLU sector

The following section discusses the links between public policies and FCC to further understand why some public policies in the AFOLU sector slowed deforestation rates and/or negatively impacted forests during and after policy implementation.

Links with policies related to conflict and post-conflict

The literature reviewed in this study reveals that conflict and post-conflict policies are related to FCC in Colombia. From these policies, those regarding illicit crops are the most frequently mentioned when studying deforestation causes in Colombia, with the main focus being on policies regarding coca eradication through aerial glyphosate spray.

Accordingly, policies related to drug eradication and pacification have influenced land-use decisions in Colombia. Some examples are the increase of deforestation in the distension zone that the Colombian government granted to the FARC at the end of the 1990s (Etter, McAlpine, Phinn, *et al.* 2006). Other examples include PLANTE and Plan Colombia in 1999, the Forest Ranger Families program. The impact of this group of policy instruments in terms of FCC, however, has not been quantified. The impacts reported to date are diverse. On the one hand, some researchers argue that the eradication program has caused leakage of illicit crops to areas where these crops were previously not found, which means that this policy could have indirectly promoted deforestation in previously unaffected areas of the northern, Caribbean and Pacific Andes (Rincón-Ruiz and Kallis 2013, Rincón-Ruiz *et al.* 2013). On the other hand, it has been reported that the Forest Ranger Families program has contributed to the mitigation of climate change through the conservation of forests and the increase of carbon stocks (ACCÍON SOCIAL and UNODC 2010, UACT *et al.* 2012).

This review demonstrated that recent studies switched their focus from coca eradication to the impact of the different post-conflict initiatives on FCC. Recent evidence suggests that some of the post-conflict policies could have enabled the implementation of environmental and conservation projects, mainly in areas where past conflict did not allow such initiatives (Castro-Nunez *et al.* 2016). However, in 2016, the year the peace treaty was signed, deforestation spiked, and the annual rate of deforestation increased by 70%, followed by a 23% increase in 2017 (González *et al.* 2018, Krause 2020, Murillo-Sandoval *et al.* 2020).

A comprehensive rural reform comprises Point 1 of the peace agreement and is regulated through Decree 902 (2017b). This reform includes several programs in order to be implemented. The land restitution program favors using the land according to its vocation and therefore could reduce pressure on forests (de la Calle and Marquez 2016). However, Decree 902 (2017b) mentions that for land to be granted back to

497 those dispossessed, the land must be sustainably exploited; otherwise, the government can reclaim the
498 land. Yet, the term sustainable exploitation is not clearly defined, and this lack of definition could lead to
499 deforestation and conflict related to ownership of the land.

500 Another important tool from the rural reform is the PDETs. In this program, the environment is lightly
501 considered through pillar 1 (Social organization of rural property and land use). However, the
502 participatory process of the PDETs has highlighted the importance of the environment for local
503 communities. Of the participatory initiatives under this pillar, 70% are related to conservation projects,
504 restoration projects, land formalization, cadaster and indigenous reserves' constitution (Agencia de
505 Renovación del Territorio 2020). In 2019, deforestation in the 170 PDET municipalities dropped by 22%
506 compared to past years. This percentage is significant compared to the national target of reducing
507 deforestation growth by 30% by 2022 (Agencia de Renovación del Territorio 2020). However, when
508 looking at the level of implementation of Point 1 of the peace agreement, only 3% of the commitments
509 have been achieved. In comparison, more than 80% of the commitments have not been initiated or have
510 been minimally initiated (KROC 2019).

511 From this group of policies, the land restitution policy (Congreso de Colombia 2011) has been
512 overlooked, despite being one of the central points of the peace agreement and acclaimed by the United
513 Nations (Forero-Nino 2012). Another policy absent from the reviewed studies is the Colombian peace
514 fund (Departamento Nacional de Planeacion 2015). The fund has a strong environmental component
515 because it promotes sustainable rural development, conservation of biodiversity and issues related to
516 climate change. There is also a need for more research on the implementation of Point 1 of the peace
517 agreement and its effects on FCC, as it can have either positive or negative impacts on forests depending
518 on its implementation and the degree of compromise from the state (Graser *et al.* 2020).
519 It is important to note that the post-conflict policies related to the AFOLU sector, and especially those to
520 conserve forests, should be carefully implemented and monitored to facilitate the assessment of the
521 impacts of these instruments on forest cover parallel to peacebuilding — while also considering that a
522 restrictive approach regarding the access and use of forests and land resources has, in some cases, created
523 conditions that prolong conflict (Brottem and Unruh 2009). Several authors suggest that even after the
524 peace agreement was signed, areas of Colombia with weak governance to implement post-conflict
525 policies will continue to deforest due to armed conflict, coca cultivation and the continued dependency on
526 an "extractivist" development model (Negret *et al.* 2019, Krause 2020, Prem *et al.* 2020)

527 ### Links with policies related to the promotion of production activities

528 According to our literature review, one of the productive sectors more frequently linked to deforestation is
529 agriculture, mainly for agribusiness and biofuel production. Agriculture for biofuel production requires

attention due to its present and potential future impacts. Boron *et al.* (2016) noted that the area for palm oil cultivation has already started to expand, primarily in natural ecosystems, thanks to the different advantages, such as tax exemptions, offered by certain statutes, namely Law 939 of 2004 and Decree 1970 of 2005.

According to Eufemia *et al.* (2019), it is likely that in a post-conflict era, some production activities will be expanded due to new investments in areas previously affected by the conflict. Therefore, these activities may negatively impact some forested areas (Robayo 2016). Hoffman *et al.* (2018) found that the government is perceived as incentivizing deforestation by fueling extractive activities, mainly oil, and extensive cattle ranching (Baptiste *et al.* 2017). Although mining activities did not prominently figure into the articles we reviewed, activities related to energy production and mining have the potential to expand deforestation in a post-conflict scenario. Thus, it is essential to quantify the impacts of these activities on FCC in a post-conflict scenario. Salazar *et al.* (2018) mentioned that the economic importance of mining activities in Colombia have been increasing in the last 20 years. Mining activities could increase after the signing of the peace agreement due to targets aimed at boosting mining and biofuel production as a way to fuel the country's economic development (Castiblanco *et al.* 2013). Therefore, the impact of mining and energy production activities could increase in the coming years if the government does not take precautionary measures.

It is still not clear how policies related to the promotion of productive activities in a post-conflict era will affect forests in Colombia. In some countries, pressure placed by those previously displaced by conflict to have land for productive activities exacerbates deforestation in post-conflict environments (Suarez *et al.* 2018). In Colombia, however, this will hinge on how the government promotes productive and extractive activities (Baptiste *et al.* 2017, Salazar *et al.* 2018, Suarez *et al.* 2018).

Links with policies related to land tenure and territorial zoning

Our literature review reveals that the link between this group of policies and FCC is not frequently explored. From this group, the policies more frequently mentioned are related to protected areas, such as indigenous reserves, lands for Afro-Colombian communities and farmers' reserves; however, these policies focus more on biodiversity conservation while the FCC issue per se tends to be excluded. Even if the efficacy of protected areas and collective lands in reducing deforestation has been thoroughly documented (Chhatre and Agrawal 2009, Oestreicher *et al.* 2009), the efficacy of farmers' reserves, which is a mechanism designed to contribute to peacebuilding in Colombia, remains an unresolved matter.

Despite being sporadically mentioned in the literature, several impacts on FCC by these land tenure and territorial zoning policies have been identified. Some policies had negative impacts, such as the Law 160 (1994) that determines access to land for agricultural activities that, through its mechanism for land distribution, has influenced the conversion of forests to pastures for cattle raising (Nepstad, Irawan, *et al.* 2013). The mechanism stipulates that landholders must demonstrate economic use of at least two-thirds of their land in order to be formally recognized as owners. Other policy instruments have had positive impacts on forest conservation; nevertheless, the benefits derived from these instruments could be greater if there was no overlap with other land tenure instruments that organize the territory. For instance, the law on forest reserves (Law 2 from 1959) established a framework under which decisions related to land-use and territory occupation were to be made. It took into consideration colonization processes, socio-economic dynamics and criteria for the conservation of the country's natural assets. A high demand for the establishment of agricultural production systems, however, produced land-use conflicts and deforestation within the forest reserves. Moreover, the demand for land to satisfy the commitments laid out in the peace agreement may generate new conflicts in land-use because of the possibility to remove areas suitable for agriculture from the forest reserves (as an alternative to accomplish the land restitution law).

Links with policies related to conservation and sustainable management of forests and natural resources

The literature review did not yield a significant number of articles regarding conservation and sustainable management (besides policies regarding protected areas mentioned in the previous subsection). This could be explained by the fact that reforestation and forest regeneration are some of the topics overlooked in the Colombian research related to FCC. However, several policy instruments designed to conserve forests and natural resources have been implemented by the government. Although it is possible to claim that deforestation in Colombia prevails despite the implementation of these instruments (Galindo *et al.* 2014), there is evidence of success related to reforestation and forest regeneration in specific contexts. For example, some studies link the reforestation and recuperation of forest cover in the Andean region to the objective of protecting hydrological basins in the area (Sánchez-Cuervo *et al.* 2012). However, socio-economic, geographic and other local conditions that could have influenced the positive impact of policies on forest conservation and natural resources protection have not been assessed. The suitability of including these instruments as part of the national policy against deforestation has been timidly considered.

The PES system has also gained increasing attention in the literature. In Colombia, the PES system prioritizes vulnerable communities affected by conflict (Decree 870 2017); however, to avoid unintended effects such as community rejection of this type of project, the community's early involvement is needed

(Lliso *et al.* 2020). Although some authors argue that it is an efficient tool for forest conservation (e.g., Calle 2020), there is uncertainty regarding what will happen if PES funds come to an end (Etchart *et al.* 2020). Therefore, attention must be drawn toward having strong financial schemes to prevent deforestation after a PES project is finished (Etchart *et al.* 2020). More recently, the zero-deforestation value chains (cocoa, milk, beef and palm oil) agreements fostered by the Ministry of Environment have been implemented. However, they are still in the early stages, and their success will depend on the commitments of private companies to reduce deforestation. Nevertheless, the number of studies related to zero-deforestation value chains in Colombia is expected to rise; so far, there are three studies from this review that are either related to this topic or call attention to it.

The methodology used for this study does have a few notable limitations. First, keywords used in the search have inherent limits, and the selection of keywords was based on the best results given by the search engine. Moreover, most of the work regarding FCC in Colombia has been done through large- and medium-scale spatial resolution satellite imagery, which does not allow for a finer-scale analysis within each of the proximate causes of FCC. We expect that the post-conflict scenario opens up the possibility to carry out FCC studies in Colombia at a finer scale, which will allow researchers to further unpack the key proximate causes of FCC.

In addition, the analysis can be strengthened by subsuming it within a broader analytical framework. Despite these limitations, this paper sheds light on the proximate and underlying causes of FCC in Colombia as reported in the literature and their relationships with public policy. Further research must focus on understanding and analyzing the finer details within each of the categories of the causes of FCC identified in this study.

Conclusion

This study has brought to light several gaps in research and has demonstrated how national AFOLU policies can influence FCC in a post-conflict setting. Our review has shown that the proximate and underlying causes of FCC in Colombia have changed over time, as has our understanding of them. This research has revealed that rural development policies targeting conflict and post-conflict issues are linked with FCC in Colombia — particularly those regarding eradication of illicit crops. Further research, however, is needed given the trends and the new reality in Colombia following the signing of the peace agreement. As our results show, the most frequently mentioned proximate causes of deforestation are cattle ranching and agriculture, followed by illicit crops. Meanwhile, political and institutional factors, socio-economic conditions and conflict are the most frequently mentioned underlying causes — yet regional differences within Colombia exist. Even though cattle ranching is frequently mentioned, recent studies suggest that

livestock is a tool to grab land in Colombia (e.g., Castro-Nunez, Mertz, Buritica, *et al.* 2017, Gutiérrez-Sanín and Vargas 2017). Although our literature review shows that extractive activities, such as mining, are not frequently mentioned as causes of deforestation, it is essential to assess their impacts on FCC as this sector has the potential to increase in a post-conflict scenario. Another topic in need of research is the potential of farmers' reserves — a mechanism designed to contribute to peacebuilding in Colombia — to reduce deforestation.

We expect that finer-scale analyses can be conducted in post-conflict Colombia in order to unpack the different aspects of the proximate and underlying causes of FCC (e.g., agriculture).

References

ACCÍON SOCIAL and UNODC. 2010. Informe ejecutivo: encuentro nacional de la gestión presidencial contra los cultivos ilícitos (PCI) : siete años construyendo legalidad. Bogotá: ACCÍON SOCIAL; UNODC.

Agencia de Renovación del Territorio. 2020. Informe de seguimiento a la implemantación de los PDETs 2019.

Álvarez, M.D. 2002. Illicit Crops and Bird Conservation Priorities in Colombia. Conservation Biology, 16(4), 11.

Álvarez, M.D. 2007. Environmental Damage from Illicit Drug Crops in Colombia. In: W.D. Jong, D. Donovan, and K.-I. Abe, eds. Extreme Conflict and Tropical Forests. Dordrecht: Springer Netherlands, pp. 133–47.

Armenteras, D., E. Cabrera, N. Rodríguez, and J. Retana. 2013. National and regional determinants of tropical deforestation in Colombia. Regional Environmental Change, 13(6), 1181–93.

Armenteras, D., N. Rodríguez, and J. Retana. 2009. Are conservation strategies effective in avoiding the deforestation of the Colombian Guyana Shield? Biological Conservation, 142(7), 1411–9.

Armenteras, D., N. Rodríguez, and J. Retana. 2013. Landscape Dynamics in Northwestern Amazonia: An Assessment of Pastures, Fire and Illicit Crops as Drivers of Tropical Deforestation. PLoS ONE, 8(1), e54310.

Armenteras, D., N. Rodríguez, J. Retana, and M. Morales. 2011. Understanding deforestation in montane and lowland forests of the Colombian Andes. Regional Environmental Change, 11(3), 693–705.

Armenteras, D., G. Rudas, N. Rodriguez, S. Sua, and M. Romero. 2006. Patterns and causes of deforestation in the Colombian Amazon. Ecological Indicators, 6(2), 353–68.

Armenteras, D., L. Schneider, and L.M. Dávalos. 2019. Fires in protected areas reveal unforeseen costs of Colombian peace. Nature Ecology & Evolution, 3(1), 20–3.

Baptiste, B., M. Pinedo-Vasquez, V.H. Gutierrez-Velez, G.I. Andrade, P. Vieira, L.M. Estupiñán-Suárez, M.C. Londoño, W. Laurance, and T.M. Lee. 2017. Greening peace in Colombia. Nature Ecology & Evolution, 1(4), 0102.

Blom, B., T. Sunderland, and D. Murdiyarso. 2010. Getting REDD to work locally: lessons learned from integrated conservation and development projects. Environmental Science & Policy, 13(2), 164–72.

667 Boron, V., E. Payán, D. MacMillan, and J. Tzanopoulos. 2016. Achieving sustainable development in rural
668 areas in Colombia: Future scenarios for biodiversity conservation under land use change. Land
669 Use Policy, 59, 27–37.
670 Brottem, L. and J. Unruh. 2009. Territorial Tensions: Rainforest Conservation, Postconflict Recovery, and
671 Land Tenure in Liberia. Annals of the Association of American Geographers, 99(5), 995–1002.
672 Calle, A. 2020. Can short-term payments for ecosystem services deliver long-term tree cover change?
673 Ecosystem Services, 42, 101084.
674 de la Calle, H. and I. Marquez. 2016. Acuerdo final para la terminación del conflicto y la construcción de
675 una paz estable y duradera. Habana, Cuba: Gobierno Nacional de Colombia; FARC EP, Acuerdo
676 de Paz Final.
677 Calle-Rendón, B., F. Moreno, and R. Hilário. 2018. Vulnerability of mammals to land-use changes in
678 Colombia's post-conflict era. Nature Conservation, 29, 79–92.
679 Castiblanco, C., A. Etter, and T.M. Aide. 2013. Oil palm plantations in Colombia: a model of future
680 expansion. Environmental Science & Policy, 27, 172–83.
681 Castro-Nunez, A. 2018. Responding to Climate Change in Tropical Countries Emerging from Armed
682 Conflicts: Harnessing Climate Finance, Peacebuilding, and Sustainable Food. Forests, 9(10), 621.
683 Castro-Nunez, A., Charry, Andres, Castro, Fabio, Sylvester, Janelle, and Bax, Vincent. 2020. Reducing
684 deforestation through value chain interventions in countries emerging from conflict: the case of
685 the Colombian cocoa sector. Manuscript submitted for publication.
686 Castro-Nunez, A., O. Mertz, A. Buritica, C.C. Sosa, and S.T. Lee. 2017. Land related grievances shape
687 tropical forest-cover in areas affected by armed-conflict. Applied Geography, 85, 39–50.
688 Castro-Nunez, A., O. Mertz, and M. Quintero. 2016. Propensity of farmers to conserve forest within
689 REDD+ projects in areas affected by armed-conflict. Forest Policy and Economics, 66, 22–30.
690 Castro-Nunez, A., O. Mertz, and C.C. Sosa. 2017. Geographic overlaps between priority areas for forest
691 carbon-storage efforts and those for delivering peacebuilding programs: implications for policy
692 design. Environmental Research Letters, 12(5), 054014.
693 Cavelier, J. and A. Etter. 1995. Deforestation of Montane Forests in Colombia as a result of Illegal
694 Plantations of Opium (Papaver somniferum). pp. 541–9.
695 Chadid, M., L. Dávalos, J. Molina, and D. Armenteras. 2015. A Bayesian Spatial Model Highlights Distinct
696 Dynamics in Deforestation from Coca and Pastures in an Andean Biodiversity Hotspot. Forests,
697 6(12), 3828–46.
698 Chhatre, A. and A. Agrawal. 2009. Trade-offs and synergies between carbon storage and livelihood
699 benefits from forest commons. Proceedings of the National Academy of Sciences, 106(42),
700 17667–70.
701 Congreso de Colombia. 1959. Sobre economía forestal de la Nación y conservación de recursos naturales
702 renovables.
703 Congreso de Colombia. 1994. LEY 160 DE 1994.
704 Congreso de Colombia. 1996. Política de Bosques.
705 Congreso de Colombia. 2007. Ley 1151 de 2007.
706 Congreso de Colombia. 2011. Ley 1448 de 2011.
707 Convention on Biological Diversity. 2011. Aichi Biodiversity Targets [online]. Aichi Biodiversity Targets.
708 Available from: https://www.cbd.int/sp/targets/ [Accessed 21 May 2020].
709 Dávalos, L.M., A.C. Bejarano, and H.L. Correa. 2009. Disabusing cocaine: Pervasive myths and enduring
710 realities of a globalised commodity. International Journal of Drug Policy, 20(5), 381–6.
711 Dávalos, L.M., A.C. Bejarano, M.A. Hall, H.L. Correa, A. Corthals, and O.J. Espejo. 2011. Forests and
712 Drugs: Coca-Driven Deforestation in Tropical Biodiversity Hotspots. Environmental Science &
713 Technology, 45(4), 1219–27.

714 Dávalos, L.M., J.S. Holmes, N. Rodríguez, and D. Armenteras. 2014. Demand for beef is unrelated to
715 pasture expansion in northwestern Amazonia. Biological Conservation, 170, 64–73.
716 Dávalos, L.M., K.M. Sanchez, and D. Armenteras. 2016. Deforestation and Coca Cultivation Rooted in
717 Twentieth-Century Development Projects. BioScience, 66(11), 974–82.
718 Davidar, P., M. Arjunan, P.C. Mammen, J.P. Garrigues, J.P. Puyravaud, and K. Roessingh. 2007. Forest
719 degradation in the Western Ghats biodiversity hotspot: Resource collection, livelihood concerns
720 and sustainability. CURRENT SCIENCE, 93(11), 7.
721 Departamento Nacional de Planeación. 2003. Programa de desarrollo alternativo 2003 – 2006.
722 Departamento Nacional de Planeación. 2008. Política Nacional de Competitividad y Productividad.
723 Departamento Nacional de Planeación. 2010. Política nacional de erradicación manual de cultivos ilícitos
724 y desarrollo alternativo para la consolidación territorial.
725 Departamento Nacional de Planeacion. 2015. Fondo Colombia en paz.
726 Duchelle, A.E., G. Simonet, W.D. Sunderlin, and S. Wunder. 2018. What is REDD+ achieving on the
727 ground? Current Opinion in Environmental Sustainability, 32, 134–40.
728 Etchart, N., J.L. Freire, M.B. Holland, K.W. Jones, and L. Naughton-Treves. 2020. What happens when the
729 money runs out? Forest outcomes and equity concerns following Ecuador's suspension of
730 conservation payments. World Development, 136, 105124.
731 Etter, A., C. McAlpine, S. Phinn, D. Pullar, and H. Possingham. 2006. Unplanned land clearing of
732 Colombian rainforests: Spreading like disease? Landscape and Urban Planning, 77(3), 240–54.
733 Etter, A., C. McAlpine, and H. Possingham. 2008. Historical Patterns and Drivers of Landscape Change in
734 Colombia Since 1500: A Regionalized Spatial Approach. Annals of the Association of American
735 Geographers, 98(1), 2–23.
736 Etter, A., C. McAlpine, D. Pullar, and H. Possingham. 2005. Modeling the age of tropical moist forest
737 fragments in heavily-cleared lowland landscapes of Colombia. Forest Ecology and Management,
738 208(1–3), 249–60.
739 Etter, A., C. McAlpine, D. Pullar, and H. Possingham. 2006. Modelling the conversion of Colombian
740 lowland ecosystems since 1940: Drivers, patterns and rates. Journal of Environmental
741 Management, 79(1), 74–87.
742 Etter, A., C. McAlpine, K. Wilson, S. Phinn, and H. Possingham. 2006. Regional patterns of agricultural
743 land use and deforestation in Colombia. Agriculture, Ecosystems & Environment, 114(2–4), 369–
744 86.
745 Eufemia, L., M. Bonatti, A. Castro-Nunez, M. Lana, H. Morales, and S. Sieber. 2019. Colombia's
746 inadequate environmental goals. Science, 364(6439), 444.2-445.
747 Forero-Nino, L. 2012. Colombia's Historic Victims and Land Restriction Law. Law and Business Review of
748 the Americas, 18(1), 97–104.
749 Galindo, G., J. Espejo, J.P. Ramírez-Delgado, C. Forero, C. Valbuena, J. Rubiano, R. Lozano, K. Vargas, A.
750 Palacios, S. Palacios, C. Franco, E. Granados, L. Vergara, and E. Cabrera. 2014. Memoria técnica
751 de la cuantificación de la superficie de bosque natural y deforestación a nivel nacional.
752 Actualización periodo 2012-2013. IDEAM. Bogotá, Colombia: Instituto de Hidrología,
753 Meteorología y Estudios Ambientales – IDEAM.
754 Geist, H.J. and E.F. Lambin. 2002. Proximate Causes and Underlying Driving Forces of Tropical
755 Deforestation. BioScience, 52(2), 143.
756 González, J., A. Cubillos, M. Chadid, A. Cubillos, M. Arias, E. Zúñiga, F. Joubert, I. Pérez, and V. Berrío.
757 2018. Caracterización de las principales causas y agentes de la deforestación a nivel nacional
758 período 2005-2015. FAO.
759 Graser, M., M. Bonatti, L. Eufemia, H. Morales, M. Lana, K. Löhr, and S. Sieber. 2020. Peacebuilding in
760 Rural Colombia—A Collective Perception of the Integrated Rural Reform (IRR) in the Department
761 of Caquetá (Amazon). Land, 9(2), 36.

Grusczynski, D.M. and C.F. Jaramillo. 2002. Integrating Land Issues into the Broader Development Agenda Case Study: Colombia. The World Bank, Working Paper.
Gutiérrez-Sanín, F. and J. Vargas. 2017. Agrarian elite participation in Colombia's civil war. Journal of Agrarian Change, 17(4), 739–48.
Harris, N.L., S. Brown, S.C. Hagen, S.S. Saatchi, S. Petrova, W. Salas, M.C. Hansen, P.V. Potapov, and A. Lotsch. 2012. Baseline Map of Carbon Emissions from Deforestation in Tropical Regions. Science, 336(6088), 1573–6.
Hoffmann, C., J.R. García Márquez, and T. Krueger. 2018. A local perspective on drivers and measures to slow deforestation in the Andean-Amazonian foothills of Colombia. Land Use Policy, 77, 379–91.
Hosonuma, N., M. Herold, V. De Sy, R.S. De Fries, M. Brockhaus, L. Verchot, A. Angelsen, and E. Romijn. 2012. An assessment of deforestation and forest degradation drivers in developing countries. Environmental Research Letters, 7(4), 044009.
Karsenty, A. and S. Ongolo. 2012. Can "fragile states" decide to reduce their deforestation? The inappropriate use of the theory of incentives with respect to the REDD mechanism. Forest Policy and Economics, 18, 38–45.
Krause, T. 2020. Reducing deforestation in Colombia while building peace and pursuing business as usual extractivism? Journal of Political Ecology, 27(1).
KROC. 2019. Estado efectivo de implementación del Acuerdo de Paz de Colombia 2 años de implementación. Notre Dame: Keough School of Global Affairs.
Lambin, E.F., H.K. Gibbs, R. Heilmayr, K.M. Carlson, L.C. Fleck, R.D. Garrett, Y. le Polain de Waroux, C.L. McDermott, D. McLaughlin, P. Newton, C. Nolte, P. Pacheco, L.L. Rausch, C. Streck, T. Thorlakson, and N.F. Walker. 2018. The role of supply-chain initiatives in reducing deforestation. Nature Climate Change, 8(2), 109–16.
Lambin, E.F., B.L. Turner, H.J. Geist, S.B. Agbola, A. Angelsen, J.W. Bruce, O.T. Coomes, R. Dirzo, G. Fischer, C. Folke, P.S. George, K. Homewood, J. Imbernon, R. Leemans, X. Li, E.F. Moran, M. Mortimore, P.S. Ramakrishnan, J.F. Richards, H. Skånes, W. Steffen, G.D. Stone, U. Svedin, T.A. Veldkamp, C. Vogel, and J. Xu. 2001. The causes of land-use and land-cover change: moving beyond the myths. Global Environmental Change, 11(4), 261–9.
Landholm, D.M., P. Pradhan, and J.P. Kropp. 2019. Diverging forest land use dynamics induced by armed conflict across the tropics. Global Environmental Change, 56, 86–94.
Lliso, B., U. Pascual, S. Engel, and P. Mariel. 2020. Payments for ecosystem services or collective stewardship of Mother Earth? Applying deliberative valuation in an indigenous community in Colombia. Ecological Economics, 169, 106499.
McCarthy, S. and L. Tacconi. 2011. The political economy of tropical deforestation: assessing models and motives. Environmental Politics, 20(1), 115–32.
Mendoza, J.E. and A. Etter. 2002. Multitemporal analysis (1940–1996) of land cover changes in the southwestern Bogotá highplain (Colombia). Landscape and Urban Planning, 59(3), 147–58.
Mendoza, T., Guerrero, R.D., Vargas, D.M., and Ortega, S.C. 2017. ANEXO 3: INFORMACIÓN DE SALVAGUARDAS REDD+EN COLOMBIA ÉNFASIS EN LA AMAZONIA. In: Primer resumén de información de salvaguardas REDD+ en Colombia, Enfasis en la Amazonía con referencia a los años 2013-2014.
Murillo-Sandoval, P., T. Hilker, M. Krawchuk, and J. Van Den Hoek. 2018. Detecting and Attributing Drivers of Forest Disturbance in the Colombian Andes Using Landsat Time-Series. Forests, 9(5), 269.
Murillo-Sandoval, P.J., K. Van Dexter, J. Van Den Hoek, D. Wrathall, and R. Kennedy. 2020. The end of gunpoint conservation: forest disturbance after the Colombian peace agreement. Environmental Research Letters, 15(3), 034033.

Negret, P.J., J. Allan, A. Braczkowski, M. Maron, and J.E.M. Watson. 2017. Need for conservation planning in postconflict Colombia: Letter. Conservation Biology, 31(3), 499–500.
Negret, P.J., L. Sonter, J.E.M. Watson, H.P. Possingham, K.R. Jones, C. Suarez, J.M. Ochoa-Quintero, and M. Maron. 2019. Emerging evidence that armed conflict and coca cultivation influence deforestation patterns. Biological Conservation, 239, 108176.
Nepstad, D., W. Boyd, T. Bezerra, and A.A. Azevedo. 2013. Responding to climate change and the global land crisis: REDD+, market transformation and low-emissions rural development. Philosophical Transactions of the Royal Society B: Biological Sciences, 368(1619).
Nepstad, D., S. Irawan, T. Bezerra, W. Boyd, C. Stickler, J. Shimada, O. Carvalho, K. MacIntyre, A. Dohong, A. Alencar, A. Azevedo, D. Tepper, and S. Lowery. 2013. More food, more forests, fewer emissions, better livelihoods: linking REDD+, sustainable supply chains and domestic policy in Brazil, Indonesia and Colombia. Carbon Management, 4(6), 639–58.
New York Declaration on Forests. 2019. Protecting and Restoring Forests: A Story of Large Commitments yet Limited Progress. Five-Year Assessment Report. New York Declaration on Forests, Executive Summary.
Oestreicher, J.S., K. Benessaiah, M.C. Ruiz-Jaen, S. Sloan, K. Turner, J. Pelletier, B. Guay, K.E. Clark, D.G. Roche, M. Meiners, and C. Potvin. 2009. Avoiding deforestation in Panamanian protected areas: An analysis of protection effectiveness and implications for reducing emissions from deforestation and forest degradation. Global Environmental Change, 19(2), 279–91.
Perz, S.G., C. Aramburú, and J. Bremner. 2005. Population, Land Use and Deforestation in the Pan Amazon Basin: a Comparison of Brazil, Bolivia, Colombia, Ecuador, Perú and Venezuela. Environment, Development and Sustainability, 7(1), 23–49.
Pfaff, A., E.O. Sills, G.S. Amacher, M.J. Coren, K. Lawlor, and C. Streck. 2010. Policy Impacts on Deforestation. Lessons Learned from Past Experiences to Inform New Initiatives. Duke: Duke University, No. NI R 10-02.
Pfaff, A.S.P. 1999. What Drives Deforestation in the Brazilian Amazon? Journal of Environmental Economics and Management, 37(1), 26–43.
Prem, M., S. Saavedra, and J.F. Vargas. 2020. End-of-conflict deforestation: Evidence from Colombia's peace agreement. World Development, 129, 104852.
Presidene de la República. 2017a. Decreto 870 de 2017.
Presidene de la República. 2017b. DECRETO 902 DE 2017.
Presidente de la republica de Colombia. 1974. DECRETO 2811 DEL 18 DE DICIEMBRE DE 1974.
Presidente de la republica de Colombia. 1996. DECRETO 1791 DE 1996.
Quintero-Gallego, M.E., M. Quintero-Angel, and J.J. Vila-Ortega. 2018. Exploring land use/land cover change and drivers in Andean mountains in Colombia: A case in rural Quindío. Science of The Total Environment, 634, 1288–99.
Redford, K.H., C. Padoch, and T. Sunderland. 2013. Fads, Funding, and Forgetting in Three Decades of Conservation. Conservation Biology, 27(3), 437–8.
Ricaurte, L.F., M.H. Olaya-Rodríguez, J. Cepeda-Valencia, D. Lara, J. Arroyave-Suárez, C. Max Finlayson, and I. Palomo. 2017. Future impacts of drivers of change on wetland ecosystem services in Colombia. Global Environmental Change, 44, 158–69.
Rincón-Ruiz, A., H.L. Correa, D.O. León, and S. Williams. 2016. Coca cultivation and crop eradication in Colombia: The challenges of integrating rural reality into effective anti-drug policy. International Journal of Drug Policy, 33, 56–65.
Rincón-Ruiz, A. and G. Kallis. 2013. Caught in the middle, Colombia's war on drugs and its effects on forest and people. Geoforum, 46, 60–78.

Rincón-Ruiz, A., U. Pascual, and S. Flantua. 2013. Examining spatially varying relationships between coca crops and associated factors in Colombia, using geographically weight regression. Applied Geography, 37, 23–33.

Robayo, A. 2016. Proposed Forest Reference Emission Level for deforestation in the Colombian Amazon 13 Biome for results – based payment s for REDD + under the UNFCCC.

Rodríguez, N., D. Armenteras-Pascual, and J.R. Alumbreros. 2013. Land use and land cover change in the Colombian Andes: dynamics and future scenarios. Journal of Land Use Science, 8(2), 154–74.

Romero-Ruiz, M.H., S.G.A. Flantua, K. Tansey, and J.C. Berrio. 2012. Landscape transformations in savannas of northern South America: Land use/cover changes since 1987 in the Llanos Orientales of Colombia. Applied Geography, 32(2), 766–76.

Salazar, A., A. Sanchez, J.C. Villegas, J.F. Salazar, D. Ruiz Carrascal, S. Sitch, J.D. Restrepo, G. Poveda, K.J. Feeley, L.M. Mercado, P.A. Arias, C.A. Sierra, M. del R. Uribe, A.M. Rendón, J.C. Pérez, G. Murray Tortarolo, D. Mercado-Bettin, J.A. Posada, Q. Zhuang, and J.S. Dukes. 2018. The ecology of peace: preparing Colombia for new political and planetary climates. Frontiers in Ecology and the Environment, 16(9), 525–31.

Sánchez-Cuervo, A.M. and T.M. Aide. 2013. Consequences of the Armed Conflict, Forced Human Displacement, and Land Abandonment on Forest Cover Change in Colombia: A Multi-scaled Analysis. Ecosystems, 16(6), 1052–70.

Sánchez-Cuervo, A.M., T.M. Aide, M.L. Clark, and A. Etter. 2012. Land Cover Change in Colombia: Surprising Forest Recovery Trends between 2001 and 2010. PLoS ONE, 7(8), e43943.

Seymour, F. and N.L. Harris. 2019. Reducing tropical deforestation. Science, 365(6455), 756–7.

Streck, C. and C. Parker. 2012. Financing REDD+`. In: A. Angelsen, M. Brockhaus, W.D. Sunderlin, and L.V. Verchot, eds. Analysing REDD+: challenges and choices. Bogor, Indonesia: Center for International Forestry Research, pp. 111–27.

Suarez, A., P.A. Árias-Arévalo, and E. Martínez-Mera. 2018. Environmental sustainability in post-conflict countries: insights for rural Colombia. Environment, Development and Sustainability, 20(3), 997–1015.

de la Torre, L., R. Valencia, C. Altamirano, and H.M. Ravnborg. 2011. Legal and Administrative Regulation of Palms and Other NTFPs in Colombia, Ecuador, Peru and Bolivia. The Botanical Review, 77(4), 327–69.

Tropical Forest Alliance 2020. 2017. Tropical Forest Alliance Annual Report 2016-2017. Tropical Forest Alliance 2020, Annual Report.

UACT, Carbono y Bosques, and UNODC. 2012. Contribución de los programas Familias Guardabosques y proyectos productivos a la mitigación del cambio climático. “Captura y almacenamiento de carbono en sistemas productivos y bosque natural”. Unidad Administrativa para la Consolidación Territorial-UACT ; Centro de Investigación en Ecosistemas y Cambio Global Carbono y Bosques; Oficina de las Naciones Unidas contra la Droga y el Delito-UNODC. Bogotá: DA VINCI EDITORES & CÍA S N C.

United Nations. 2015. Paris Agreement.

UNODC and Gobierno Nacional de Colombia. 2019. Colombia. Monitoreo de territorios afectados por cultivos ilícitos 2018. UNODC; Gobierno Nacional de Colombia, Reporte de Monitoro No. 2011–0596.

Unruh, J.D. 2011. Tree-Based Carbon Storage in Developing Countries: Neglect of the Social Sciences. Society & Natural Resources, 24(2), 185–92.

Urrego-Mesa, A., J. Infante-Amate, and E. Tello. 2018. Pastures and Cash Crops: Biomass Flows in the Socio-Metabolic Transition of Twentieth-Century Colombian Agriculture. Sustainability, 11(1), 117.

Van Ausdal, S. 2009. Pasture, profit, and power: An environmental history of cattle ranching in Colombia, 1850–1950. Geoforum, 40(5), 707–19.

Verburg, P.H., K.-H. Erb, O. Mertz, and G. Espindola. 2013. Land System Science: between global challenges and local realities. Current Opinion in Environmental Sustainability, 5(5), 433–7.

Vina, A. and J. Cavelier. 1999. Deforestation Rates (1938-1988) of Tropical Lowland Forests on the Andean Foothills of Colombia1. Biotropica, 31(1), 31–6.

Viña, A., F.R. Echavarria, and D.C. Rundquist. 2004. Satellite Change Detection Analysis of Deforestation Rates and Patterns along the Colombia – Ecuador Border. AMBIO: A Journal of the Human Environment, 33(3), 118–25.

Wehkamp, J., S.A. Pietsch, S. Fuss, M. Gusti, W.H. Reuter, N. Koch, G. Kindermann, and F. Kraxner. 2018. Accounting for institutional quality in global forest modeling. Environmental Modelling & Software, 102, 250–9.

Yepes, F. 2001. Ganadería y transformación de ecosistemas: un análisis ambiental de la política de apropiación territorial. In: Naturaleza en disputa. Ensayos de historia ambiental en Colombia 1850-1995. Bogotá: Universidad Nacional de Colombia, pp. 118–72.

Zarin, D.J. 2012. Carbon from Tropical Deforestation. Science, 336(6088), 1518–9.