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Peace and the environment at the crossroads: Elections in a conflict-troubled biodiversity hotspot

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ABSTRACT

In democracies around the world, societies have demonstrated that elections can have major consequences for the environment. In Colombia, the 2022 presidential elections will take place at a time when progress towards peace has stalled and socioeconomic, security, and environmental conditions have deteriorated. The recent declines in these conditions largely coincide with the change of government after the 2018 elections, and the associated rise to power of a party that boycotted the peace negotiations from the beginning. These indicators suggest that 2018 marked the end of a decade of improvements in safety, wealth, and equality—societal factors that can interact with the environment in multiple ways. A spike in assassinations of land and environmental defenders in 2019 and 2020 made Colombia one of the most dangerous places in the world for environmentalists. With the 2022 presidential election, Colombians will once again decide who will govern the country and what new social, economic, and environmental policies will be implemented. In preparation for elections like this, we believe that it is important for scientists with relevant backgrounds to highlight relationships between political events and the environment, to enrich the political debate, help prioritize public resources, and inform policy-making. Here, we provide a multidisciplinary analysis of different socioeconomic and environmental trends that can help inform the public and decision-makers. We intend for this analysis to be useful not only in Colombia, but also to other societies under similar situations, managing biodiversity-rich ecosystems in socio-political environments of increasing violence, poverty, and inequality.

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1. Introduction

Protection of the environment often depends on governmental policies and their enforcement. Environmental policies have direct effects when enforced, while other policies may indirectly affect the environment through their influence on societal conditions. Thus, changes in governments can have dramatic consequences for the environment. In tropical countries like Brazil, Indonesia and Honduras, deforestation rates cycle with democratic elections (Burgess et al., 2012; Middeldorp and Le Billon, 2019; Ruggiero et al., 2021). This coupled cycling has been linked to political corruption via reduced enforcement of illegal logging (Burgess et al., 2012), resource-based exploitation licenses granted by newly elected governments (Middeldorp and Le Billon, 2019), and to administrative inefficiency during government shifts (Rodrigues-Filho et al., 2015).

In Colombia, the political debate of recent decades has almost entirely focused on issues related to conflict, primarily from a military perspective. This framing largely overlooks the indirect consequences of conflict and of governmental policies on the environment, as well as the possibility of conflict being triggered or fueled by environmental deterioration (Homer-Dixon et al., 1993; Diehl, 2018; Gleditsch, 2018).

In democratic societies, it is important for researchers with relevant backgrounds to study the relationships between government policies and their environmental consequences, and to communicate their findings to policymakers and the general public, to help inform future policy and decisions such as voting. Here, we provide a multidisciplinary analysis of links between governmental and societal transitions and environmental consequences in Colombia. Our case study of this conflict-troubled biodiversity hotspot can help inform the public before the presidential election of 2022.

2. Socio-political context

2.1. The trends of peace

After about 50 years of disruptive conflict with internal rebel groups, the Colombian government entered a period of fruitful peace talks in the 2010 s. Metrics of public safety improved from 2012 to 2016, as the Colombian government negotiated for peace with FARC, an ex-guerrilla group. During this period the number of yearly massacres (defined by the Colombian Ministry of Defense as the killing of four or more civilians in a single event; Mindefensa, 2021) decreased from 33 to nine (Fig. 1a), and the number of people killed in these events decreased from 156 to 38—the lowest rates since at least 2010 for both metrics. Similarly, the number of terrorist attacks decreased from 584 in 2012 to a low of 125 in 2017 (Fig. S1c; Mindefensa, 2021); the number of ELN (the second-largest guerrilla group in Colombia) members voluntarily demobilizing increased from a decadal minimum of 159 in 2012 to a maximum of 433 in 2018 (Fig. S1e, Mindefensa, 2021); and the number of people being internally displaced by force decreased from a decadal maximum of ca. 260,000 in 2013 to less than 100,000 in 2017 (Fig. S1; IDMC, 2021). Together, these trends show how internal conflict decreased in rural areas of Colombia between the beginning of the peace negotiations in 2012 and the election year of 2018.

Economic conditions of the poor improved in parallel with the metrics of safety. The poverty index of the Colombian Administrative Department of Statistics (DANE) steadily decreased from 40.8 in 2012–36.2 in 2016 and continued to a low of 34.7 in 2018 (Fig. 1b). The poverty index reported by the World Bank followed a similar trend (Fig. 1b). Both entities also reported steady decreases of the Gini-inequality index between 2010 and 2017, during the negotiation and early implementation of the peace agreement (Fig. 1c). In summary, Colombia's indicators of peace, wealth and equality improved substantially during most of the last decade. Some of these indicators, such as the total number of massacres (Fig. 1a) and the number of social leaders killed per year (Fig. S1a), started improving even before the

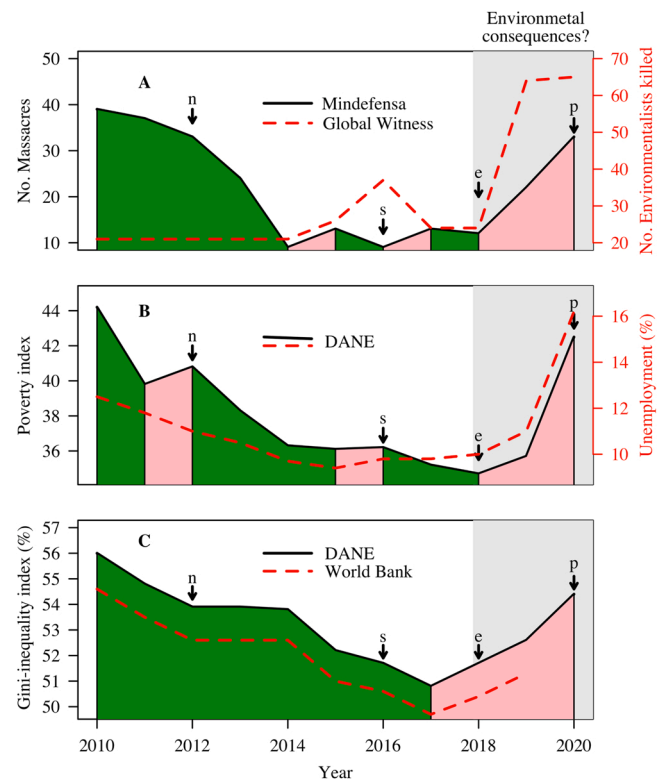


Fig. 1. Indicators of social health relative to the timing of recent political and societal events in Colombia. a) Number of massacres (so-called group killings; Mindefensa, 2021) and number of land and environmental defenders killed (Global Witness, www.globalwitness.org; data for 2010 and 2014 were calculated based on 105 killings between 2010 and 2015; Statista, www.statista.com); b) Poverty index (DANE, 2020, percentage of people in poverty; similar trend reported by the World Bank, 2021) and unemployment (%; https://www.dane.gov.co/); c) The Gini index of income inequality (DANE and World Bank, 2021). n: beginning of peace negotiations; s: signing of peace agreement; e: election year; p: COVID-19 pandemic's onset. The grey background between 2018 and 2020 highlights the rapid deterioration of socio-economic conditions in Colombia during that period, which coincides with the beginning of the 2018–2022 administration. In the case of poverty and inequality, there is an even greater increase during the COVID-19 pandemic. The colored backgrounds highlight periods where socio-economic factors either improved or remained unchanged (green), or worsened (pink).

peace negotiations. Others, like the number of terrorist attacks (Fig. S1c) and the number of internal forced displacements (Fig. S1d), worsened before the peace talks. All these social factors have the potential to affect the environment in multiple ways (Section 3).

2.2. A socio-political breaking point

While safety, wealth and equality had increased in Colombia during the negotiation and early implementation of the peace process, these trends reversed in the election year of 2018 (Fig. 1). Over the next two years, these metrics regressed by a decade or more, to levels last seen at the beginning of the peace negotiations. In the 2018 election, the presidency was won by a political party that had previously campaigned against the peace process. After the election, from 2018 to 2020, the number of yearly massacres increased from 12 to 33 (in 2020; Fig. 1a), and deaths in massacres increased from 70 to 172 (Mindefensa, 2021). Most of the killings after the signing of the peace agreement targeted groups that often played key roles in the protection of the environment, including land and environmental defenders (Fig. 1a), social leaders and human-rights defenders (Fig. S1a), local farmers, environmentalists, and indigenous people (Global Witness, 2021; Indepaz, 2021).

The rise in these politically slanted killings after 2018 was dramatic. Assassinations of environmentalists spiked to levels two or three times higher than had been seen that decade (Fig. 1a). In 2019 and 2020, more land and environmental defenders were killed in Colombia than in any other country in the world (Global Witness, 2021). In 2020, more than half of the global murders of environmental defenders occurred in Colombia alone (FLD, 2020). Environmentalists were not the only target group. The number of social leaders and human rights defenders murdered between 2018 and 2020 was also the highest in the last decade (Indepaz, 2020a; Fig. S1). Assassinations of indigenous leaders increased from 31 in 2016–84 in 2019 (42 in 2020, until June 8th; Indepaz, 2020b). Indigenous people represent less than 5% of the Colombian population, but 37% of all the killings (Correa-Salazar et al., 2021). Together, Afro-Colombian and indigenous communities have been the ethnic groups most affected by forced armed displacement in Colombia (Shultz et al., 2014; Vélez-Torres and Méndez, 2022). 59% of the Colombian territory is forest and 48% of that land are Indigenous territories (29 million ha; DANE, 2018; El Espectador, 2020).

The government's attitude towards peace negotiations can also affect the environment by changing the degree to which people are displaced by conflict (Sánchez-Cuervo, 2013). As a result of internal conflict and natural disasters, Colombia has a large number of internally displaced people (IDMC, 2021), mostly in rural areas (Fig. S3). Forced displacement decreased markedly from 2013 to 2017, but increased again to ca. 140,000 people in 2018 (Fig. S1d). Displacement decreased to its decadal minimum of 75,000 people in 2019, but in 2020, again exceeded 100,000 (Fig. S1d). During the first five months of 2021, almost 30,000 people were displaced, representing a 100% increase compared to the same period in 2020 (IDMC, 2021). In Colombia, displacements caused by conflict are of a similar magnitude as those driven by climate-related events (e.g., 64,000 new displacements caused by disasters in 2020; IDMC, 2021). The combination of these two types of forced migration have had profound effects on the country's landscape.

The peace process allowed people to return to formerly conflict-ridden rural areas. As the returning population increasingly used the natural resources, it contributed to deforestation and increases in forest fires, especially in the Amazon (Armenteras et al., 2019; Clerici et al., 2020) and the Andes-Amazon transition regions (Murillo-Sandoval et al., 2020). The spike of killings and forced displacement since 2018 could again result in land abandonment and unintentional forest regrowth in many areas. However, forest regrowth will not occur in areas where opportunists occupy vacated areas and use them for legal or illegal land-intensive activities (Fergusson et al., 2014; Davalos et al., 2021).

The long-standing Colombian conflict also degrades measures of societal well-being such as income and equality; these changes can increase the risks of long-lasting environmental deterioration (Vallejo and Caicedo, 2020; Wright et al., 2007). The 2018 election year marked an end to a decade-long improvement in Colombia's wealth and income equality (Fig. 1b, c). Between 2018 and 2019, the poverty index in Colombia increased one point (the largest increase since 2011), and in the first year of the COVID-19 pandemic, it climbed up c.a. 5 more points, to a level not seen since 2010 (Fig. 1b). Similarly, unemployment, an essential factor for the Sustainable Development Goals (SDGs), consistently decreased before, during and immediately after the peace negotiations (except in 2016; Fig. 1b). However, unemployment increased again to 10% in 2018, and it has been on the rise to a decadal maximum of 16.2% in 2020 (DANE, 2020; Fig. 1b). Income inequality also increased in 2018 for the first time in a decade and continued increasing to 54.4% in 2020, a level not seen since the beginning of the peace negotiations (Fig. 1c).

3. Relationships between societal factors and the environment

The increases in violence, poverty, and inequality in Colombia since 2018 (Fig. 1) can affect the environment in various ways (Table 1).

Table 1

Potential relationships of violence, poverty and inequality with the environment.

Social factor	Relationship with the environment
Violence/ Peace	Killing of land and environmental defenders (e.g., in contexts of extractive economies or land dispossession; Correa-Salazar et al., 2021; Le Billon and Lujala, 2020) → Jeopardizes the creation and implementation of projects that benefit the environment, and the achievement of sustainable development goals (UN, 2021). Forced displacement (e.g., from cattle ranges and crop lands) → land abandonment → Unintentional reforestation (Sánchez-Cuervo, 2013), partial habitat restoration for wildlife, carbon sequestration in plant biomass, soil recovery, increased water security. Forced displacement from forested land → Transformation of land for land-intensive legal or illegal businesses → Deforestation (Fergusson et al., 2014; Davalos et al., 2021), habitat fragmentation, biodiversity loss, increased greenhouse gas emissions, soil erosion, air pollution via intentional fires, reduced water security. Pollutants used in illegal economies like cocaine production (Alvarez, 2007) or illegal mining (Palacios-Torres et al., 2018) → Precarious use and disposal → Long-term soil and water contamination, health impacts, biodiversity loss. Terrorist attacks with high environmental impacts (e.g., bombing of oil pipelines; Fig. S1b) → Long-term soil and water contamination, biodiversity loss (Ríos et al., 2021). "Narco-economies" reinvesting revenues into activities that cause deforestation (e.g., land grabbing, timber poaching, gold mining, and flora and fauna trafficking) → "Narco-deforestation" (McSweeney et al., 2014; Sesnie et al., 2017) and "Narco-degradation" of the environment (Devine et al., 2021).
Wealth/ Poverty	Poverty → Dependence on local natural resources for subsistence → Deforestation for fuel (Vallejo and Caicedo, 2020), mining and land grabbing → Habitat fragmentation, biodiversity loss, soil erosion, air pollution via intentional fires, reduced water security. Poverty reduction → Increases in the purchase of land- and energy-intensive goods → Increased environmental footprint (e.g., CO ₂ emissions; Malerba, 2020). Poverty and corruption → Higher density of fires within tropical forest reserves (Wright et al., 2007) → Habitat fragmentation, biodiversity loss, increased greenhouse gas emissions, soil erosion, air pollution via intentional fires, reduced water security. Unemployment → Decreases in pro-environmental behaviors that require financial contributions, and increases in time/effort-intensive pro-environmental behaviors (Meyer, 2016).
Equality/ Inequality	Inequality → Erodes land-sparing effect of agricultural productivity (Ceddia, 2019) → Deforestation → Habitat fragmentation, biodiversity loss, increased greenhouse gas emissions, soil erosion, air pollution via intentional fires, reduced water security. Land inequality → Low access to land where an agricultural frontier is already well-established → Economic opportunities from clearing land → Deforestation → Habitat fragmentation, biodiversity loss, increased greenhouse gas emissions, soil erosion, air pollution via intentional fires, reduced water security (Sant'Anna, 2017).

Environmental impacts from some of these factors, such as the rampant killing of environmental defenders, are widespread, irreversible, and unmeasurable.

Overall, the risks of environmental deterioration increase with violence, poverty and inequality. This can be through killings of environmental and rural leaders, extensive forced displacement or terrorist attacks that cause high environmental damage, like the bombing of pipelines (Table 1), or by eroding the land-sparing effect of agricultural productivity (Ceddia, 2019). Although a reduction in violence, poverty and inequality usually benefits the environment, in some cases it can unintentionally have the opposite effect. For example, a reduction of poverty can increase the purchase of land- and energy-intensive goods (Malerba, 2020). Election years can be break points for the trajectories of socio-economic trends affecting the environment (Fig. 1).

4. A changing environment

The changing socio-political realities in Colombia in the last decade have coincided with changes in the country's environment. In general,

during the negotiation of the peace agreement, there were lower rates of tree cover loss (national estimates; Global Forest Watch, 2021) and GHG emissions related to agriculture (Ag) and land-use change and forestry (LUCF) (national estimates; Climate Watch, 2021), and lower fire counts (values from three protected areas, or PAs, in the Amazon region; Tebbutt et al., 2021) than in the years after the agreement (Fig. 2). These trends occurred while the economy prospered and there were reductions in poverty and unemployment. Several break points in environmental trends coincide with the signing of the peace agreement, the election year of 2018, and/or the COVID-19 pandemic.

4.1. Relationships between the economy and the environment

The economic and environmental trends in Colombia in the last decade are one additional piece of evidence that challenges an idea that protecting the environment hinders economic growth (Fig. S2; Cordero et al., 2005). From 2010 until the signing of the peace agreement, Colombians not only enjoyed sustained reductions in poverty (Fig. 1b; including extreme poverty, Fig. S4) and unemployment (Fig. 1b), but reduced their annual LUCF and Ag GHG emissions—the two largest sources of emissions in the country in the last decade (Climate Watch, 2021)—from a maximum of 147 to a minimum of 113 Mt CO₂e (Fig. 2a). This trend reversed around the time that the peace agreement was signed, as tree cover loss (Fig. 2a) and fire counts (Fig. 2b) increased rapidly. Since then, tree cover loss and fire counts have remained high

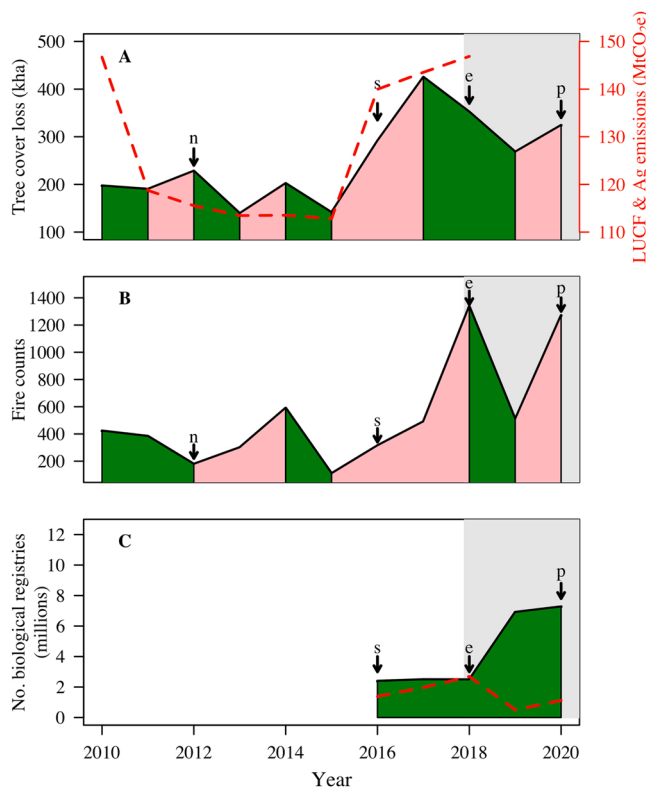


Fig. 2. Trends of major environmental indicators in Colombia between 2010 and 2020. a) Tree cover loss (Global Forest Watch, 2021) and agriculture (Ag) plus land-use change and forestry (LUCF) CO₂ emissions (Climate Watch, 2021). b) Fire counts (Tebbutt et al., 2021). c) Number of national (black, solid line) and international (red, dashed line) biological registries (i.e. data about the location of a species, or another taxon, at a given place and time) to SiB (Spanish abbreviation for National Biodiversity System of Colombia; Escobar et al., 2020). n: beginning of peace negotiations; s: signing of peace agreement; e: election year; p: COVID-19 pandemic's onset. Grey background, as in Fig. 1, for comparison purposes. The colored backgrounds highlight periods where socio-economic factors either improved or remained unchanged (green), or worsened (pink).

(Fig. 2a, b). Both metrics rose between 2019 and 2020 (Fig. 2a, b), as did deforestation (+8%, reaching 171,685 ha in 2020; IDEAM, 2021a), and the emergence of new ‘seeds’ of deforestation hotspots in the Amazon (Fig. S5; InSight Crime, 2021; IDEAM, 2021a). Several of these new hotspots spatially coincide with sporadic or oscillatory hotspots between 2001 and 2015 (Hettler et al., 2017). Many illegal mining locations—which increased in number after the signing of the peace agreement (Massé and Le Billon, 2018)—and new patches of deforestation concentrate around rivers like the Caquetá and Putumayo (Fig. S5). The potential growth of those new hotspots threatens large regions of the Colombian Amazon.

A purported “dilemma,” or tradeoff between economic growth and environmental protection has been presented by some political forces in Latin America and beyond (Cordero et al., 2005). The simultaneous improvements in Colombia’s economy and environment from 2010 to 2016 illustrate the fallacy of that false dilemma. During this period, that included the years when the peace negotiations took place, Colombians became wealthier and more equitable while tree cover loss, greenhouse gas emissions and fire counts either decreased or remained at their decadal lowest (Figs. 1b,c, 2a). More recently, simultaneous degradation of economy and environment provided further evidence against any tradeoff: since the 2018 elections, major indexes of environmental deterioration in Colombia reached a decadal maximum (Fig. 2), as did poverty, unemployment and income inequality (Fig. 1).

4.2. A changing climate

Socio-economic changes are influencing Colombian ecosystems at a time when the climate is also changing (Salazar et al., 2018). Over the last century, Colombia’s mean annual temperature increased ca. 1 °C, and glacier-covered area decreased by 90% (based on the aggregated area of five glaciers: Cocuy, Santa Marta, Huila, Santa Isabel, and Tolima; IDEAM, 2021b). The most recent report from the Intergovernmental Panel on Climate Change (IPCC, 2021) assesses that northwestern South America (western Colombia and Ecuador) and northern South America (eastern Colombia, Venezuela, Surinam and the Guianas) have experienced an increasing frequency and intensity of hot extremes since the 1950 s due to human activity, and these trends are projected to continue with additional global warming (IPCC, 2021; Arias et al., 2021; Seneviratne et al., 2021). 21st-century projections under different scenarios suggest increases in mean annual precipitation and decreases in snow, glacier and ice sheet covers over northwestern South America. Models also project increases in the frequency and intensity of agricultural and ecological droughts and fire weather conditions (e.g., hot, dry and windy conditions), as well as decreases in mean precipitation, over northern South America throughout the 21st century (Pabón-Caicedo et al., 2020; Almazroui et al., 2021; Arias et al., 2021, b; Douville et al., 2021; Ortega et al., 2021; Reboita et al., 2021). This assessment shows that climate conditions over Colombia are changing and will continue changing during this century, putting increasing pressure on ecosystems and human systems already endangered in the country.

Elections can provide an opportunity to strengthen mitigation and adaptation responses to climate change, if voters elect politicians or parties that prioritize relevant investment in public resources. In Colombia, climatic events like El Niño and La Niña can cause economic damages equivalent to several percentage points of the Gross Domestic Product (GDP; e.g., 2.7–2.3% in 2010–2011; Hoyos et al., 2013). Environmental deterioration, overall, is even more costly (3.5% of GDP in 2014; Minambiente et al., 2014). It is very likely that rainfall variability related to El Niño and La Niña will increase in the second half of the 21st century, with consequences for ecosystems and societies (Arias et al., 2021). Colombian governments have been ambitious at setting climate-change-related goals. In 2020, the Colombian 2018–2022 administration announced two new targets for 2030: net-zero deforestation and a reduction of 51% of the country’s GHG emissions

(Minambiente, 2021b). However, the administration's commitment to these initiatives, and the protection of the environment in general, is not reflected in the General Nation's Budget (PGN, for its abbreviation in Spanish; Fig. S6). The participation of the Environment and Sustainable Development sector in the 2018–2020 PGN is among the lowest in a decade (data from Sarmiento et al., 2017 and Contraloría, 2018, 2020; Fig. S6).

The current pledges to the Paris Agreement by the Colombian government follow a path consistent with increases in global mean temperature about 3–4°C by the end of the 21st century, and therefore are “highly insufficient” to meet this agreement (Climate Action Tracker, 2021; El Espectador, 2021c). Much of the Colombian “nationally determined contribution” towards reaching the global goals of this agreement relies on land-based mitigation measures (~70% of the reductions needed for this updated target). However, relevant metrics such as deforestation rates and fire counts are trending in the wrong direction (Fig. 1a, b). In 2019, CO₂ emissions from fossil fuels reached a record high of 102 Mt, representing a 17% increase compared to the 2010–2018 period (Fig. S2). In June 2021, the Colombian Congress rejected a bill aimed to forbid fracking and the exploitation of unconventional deposits in Colombia (El Tiempo, 2021). In addition, the Colombian government promotes the expansion of natural gas extraction (Laws No. 2099 and No. 2128; Presidencia de la República de Colombia, 2021a,b). For instance, Ecopetrol and Shell EP Offshore Ventures Limited agreed on exploiting the largest natural gas deposit found in deep waters of the Colombian Caribbean (Shell, 2020). Both fracking and natural gas extraction are linked to methane leaks (Alvarez et al., 2018; Washington Post, 2018; Scientific American, 2020; Zhang et al., 2020; Lin et al., 2021). Meanwhile, despite these actions, the Colombian Government was among the countries that signed a pledge on methane reduction in COP26 (Portafolio, 2021; UNFCCC, 2021). Elections provide opportunities for citizens to elect politicians who will distribute public resources to address the risks of environmental deterioration and climate change.

4.3. Peace and biodiversity

Colombia harbors much of the world's undiscovered biodiversity (Moura and Jetz, 2021). There, and in similar tropical countries, deforestation and other anthropogenic disturbances drive rapid biodiversity loss (Barlow et al., 2016; Betts et al., 2017). Yet, we know of no estimates of how the country's biodiversity is changing over time. In Colombia there are between 200,000 and 900,000 non-microbial species (Mora et al., 2011; Arbeláez-Cortés, 2013; SiB, 2021). However, these estimates remain highly uncertain, in part due to the difficulties of collecting biological samples in areas affected by conflict. Biodiversity estimates are urgently needed, for example, to help direct national and foreign conservation resources towards areas where biodiversity is being lost most quickly.

The signing of the peace agreement allowed the return of field scientists to vast areas previously inaccessible because of the conflict, leading to the discovery of hundreds of new species (Botero, 2020). Since the year of the peace agreement, the number of biological registries (i.e. data about the location of a species, or another taxon, at a given place and time) in the National Biodiversity System of Colombia (SiB, for its abbreviation in Spanish) spiked (Fig. 2c; Escobar et al., 2020). This increase does not reflect an actual increase in the abundance or richness of wildlife in Colombian ecosystems. However, it does highlight the benefits of peace for field expeditions that create databases that help protect the country's rich biodiversity and associated ecosystem services.

The launching of programs like Colombia Bio—a government project that began soon after the peace agreement and that aimed to explore and register biodiversity in places formerly affected by the conflict with FARC (Botero et al., 2020)—contributed to the ca. 7 million biological registries per year in 2019 and 2020 (Fig. 2c; Escobar et al., 2020) to the

SiB. The rest of the world contributed fewer than 2 million biological registries per year over the same period (Fig. 2c; Escobar et al., 2020). Before a new registry can be incorporated into databases like SiB, samples need to be collected, processed, and analyzed. Hence, new SiB registries in 2019 and 2020 are likely of specimens collected one or two years earlier. With the spike of violence in rural Colombia since 2018, and the killings of environmentalists in the country (Fig. 1a), the discovery and registration of species in the coming years may be slowed down, limiting the availability of biodiversity information to improve the well-being of Colombians and wildlife.

4.4. Environmental policies after the peace agreement

Governments can directly affect the environment through their environmental policies. In Colombia, the signing of the peace agreement coincided with the beginning of a four-year trend of annual reductions in some crimes against the environment and natural resources, including illegal exploitation of fauna and flora (Law 599, 2000; Fig. S1f). During this time, the Colombian army created “environmental battalions”—an attempt to redirect the army's efforts with the promise of more peaceful times.

In 2018 there was a change in environmental policies toward a more punitive approach. According to the 2018–2022 Colombia's National Development Plan (NDP, 2018), the transition to licit agricultural production needs to be enforced through police and military interventions, through the creation of “Strategic Zones of Comprehensive Intervention” (NPD, 2018). This policy is the result of the definition, for the first time in Colombian history, of environmental degradation as a national and international security priority (Gilberti, 2020). The policy has been implemented via controversial military operations like *Artemisa* (Rodríguez-de-Francisco et al., 2021).

Artemisa resulted in at least 13 military interventions between 2018 and 2021, seven of which were carried out before the COVID-19 pandemic (Rodríguez-de-Francisco et al., 2021; El Espectador, 2021a). With the support of the Chief Prosecutor's Office, the Ministry of the Environment, and the Institute for Hydrology, Meteorology and Environmental Studies (IDEAM), *Artemisa* aimed to curb deforestation in some Protected Areas (PAs) of the Amazon region (Amador-Jiménez et al., 2020). However, *Artemisa* has mainly focused on reducing deforestation caused by local farmers with small plots of land, while actors financing large-scale deforestation, well-positioned within webs of political and economic power, have not been targeted by such environmental enforcement (Gilberti, 2020; Murillo-Sandoval, 2020; Pardo-Ibarra, 2021; Rodríguez-de-Francisco et al., 2021).

Additionally, in June 2021, the Colombian government enacted a law that penalizes deforestation (Law, 2111, 2021; Minambiente, 2021a). Yet at the same time, the ruling political party and its allies played a leading role in blocking both the ratification of the Escazú Agreement (Archyde, 2021), a treaty that pledges multilateral efforts toward the protection of the environment and its defenders; and the implementation of the Agrarian Specialty project, an initiative aligned with the goals of the peace agreement aiming to facilitate resolutions to land disputes (El Espectador, 2021b). If, like with *Artemisa*, the implementation of the law against deforestation does not tackle large-scale deforestation and land grabbing, and more structural issues underlying deforestation, then there is no reason to expect significant reductions in the rates of tree cover loss and fire counts, or in the GHG emissions and biodiversity loss caused by deforestation. Also, if the lack of political support for initiatives like the Escazú Agreement and the Agrarian law reflects the government's priorities, it would be reasonable to expect the widespread killings of environmentalists and land defenders to continue.

Following the peace agreement, deforestation rates accelerated in national protected areas. These areas contain high biological diversity and cultural values, and provide important ecosystem services (Clerici et al., 2020). However, these “protected” areas often lack an effective institutional presence, which makes them susceptible to extensive land

grabbing and to the expansion of illicit crops. Coca cultivation in Colombia increased between 2014 (78,000 ha) and 2020 (245,000 ha), with the largest increase (+33,000 ha) between 2019 and 2020 (Fig. S7; ONDCP, 2021). However, in 2020 only about 8% of deforestation in Colombia was directly linked to coca cultivations (IDEAM, 2021a). The remaining 92% was related to land grabbing linked to cattle ranching, African palm cultivation, illegal logging, and illegal mining (Fig. S4). To fight the deforestation caused by coca cultivations, the 2018–2022 administration signed a bill that authorizes the resumption of aerial applications of glyphosate-based herbicides (Minjusticia, 2021). Previous estimates suggest that the efficacy of removing illicit crops through aerial application of glyphosate is 3% (ca. 30–35 ha treated for 1 ha eradicated; Mejía et al., 2017). Eradication of illegal crops via aerial spraying often increases conflict (Davalos et al., 2021). Aerial application of glyphosate was suspended in 2015 because of its poor performance and risks to humans and the environment (especially due to the use of adjuvants; Sánchez, 2021). The governmental approval in 2021 makes Colombia once again the only country in the world to permit aerial spraying of glyphosate for counter-drug purposes (UNODC, 2019).

The time of the peace negotiations coincided with the decade's largest reduction in the number of terrorist attacks on pipelines, which cause substantial environmental contamination (Fig. S1b; Mindefensa, 2021). The numbers of these attacks decreased from 144 in 2013–17 in 2016. After the signing of the peace agreement, the number of attacks increased to 74 in 2018, before decreasing to 31 by 2020. The peace negotiation, the signing of the peace agreement and the election year of 2018 appear to be break points in the decadal trends of these environmentally polluting, conflict-related events (Fig. S1b), suggesting that these national political events may have had important environmental consequences at the local scale.

4.5. Environmental footprint of political decisions in times of the COVID-19 pandemic

The year 2020 marked the COVID-19 pandemic outbreak. As in the rest of the world, widespread confinement of urban populations had noticeable effects on the environment. In Colombia, 2020 saw a substantial acceleration of deforestation (IDEAM, 2021a; Global Forest Watch, 2021), as well as an increase in the number of forest fires (Fig. 2b; Amador-Jiménez et al., 2020). This is likely the effect of a reduced enforcement capacity of the government, while illegal groups increased their pressure on the natural environment.

The pandemic's effects on the environment are linked to governmental decisions. Colombia has been ranked among the ten worst-performing countries in managing the COVID-19 pandemic (Lowy Institute, 2021). Attempts by the 2018–2022 administration to tax people (tax reform) during the worst economic hit of the pandemic caused massive protests. This, coupled with delayed vaccine acquisition (WLRN, 2021), created conditions that likely increased the spread of infections. The ways the government managed the pandemic may have contributed to the disproportionate increase in extreme poverty compared to other countries in 2020 (Fig. S3). Deterioration of socio-economic conditions due to a poor management of the pandemic can negatively impact the environment in multiple ways (Section 3).

4.6. Measures to protect natural resources and biodiversity in rural areas

Colombia is one of the most inequitable countries in terms of land distribution, with a Gini coefficient of land distribution higher than 0.8 (0 and 1 meaning minimum and maximum inequality, respectively; PNUD, 2011). A mere 0.25% of rural properties make up 74% of the country's total land (Garay and Espitia, 2019). Of the rural municipalities, only 6% have a total degree of land registered in the national system, while the rest, 94% of the land is unregistered (DNP, 2015). Such inequity has been one of the central causes of the armed conflict in Colombia during the last 60 years (CMH, 2016). The main goal of the

first chapter of the peace agreement was to reduce this large rural inequality and land informality (i.e. not registered in the National System) via an "Integral Rural Reform" (Acuerdo final, 2016). However, this is the least developed chapter of the peace agreement, with only 4% of the activities completed as of 2020 (Fig. S8; Kroc Institute, 2020).

After the signing of the peace agreement, the 2014–2018 and 2018–2022 Colombian administrations presented bills that would have implemented and strengthened the "agrarian jurisdiction." This jurisdiction would oversee justice in rural areas, focusing on the protection of the most vulnerable communities in relation to land tenure and agricultural production. The last bill (No. 395 of 2021) had a strong emphasis, among others, on judicial resolution of rural conflict. However, both bills were shelved by the Senate. Implementing the integral rural reform and an agrarian jurisdiction could play critical roles in deterring land grabbing and deforestation. State building and biodiversity protection in peripheral areas are pending issues for the next government.

5. Elections and the environment

Elections can affect the environment (Rodrigues-Filho et al., 2015; Ruggiero et al., 2021). With upcoming elections in Colombia, there are at least two major environmental risks: an immediate risk during elections, and a potentially longer-lasting risk afterwards. In the short term, the levels of corruption, poverty and inequality in Colombia suggest a high risk of a spike of deforestation during political elections, including via "rent paying" with natural resources (Burgess et al., 2012). In the long-term, Colombians are at a risk of electing a government that contributes, through action and/or inaction, to perpetuating the deterioration of socio-economic conditions in the country, and its long-lasting effects on the environment (Salazar et al., 2021). A sustainable relationship between societies and their environment requires commitments over periods of time longer than the presidential periods of democratic countries. However, our analysis suggests that election years can serve as breakpoints in major socio-economic and environmental trends.

For decades, elections in Colombia have gravitated around internal armed conflict (e.g., Weintraub et al., 2015), while the environmental consequences (within and beyond the country) of conflict for this biodiversity hotspot, and the government's approaches to addressing it, have rarely been examined. Here, we have analyzed break points in socio-economic trends that coincide with the election year of 2018, and that can have profound and long-lasting consequences on the environment, including an alarming spike in the assassinations of land and environmental defenders to numbers not seen in any other year in the last decade or any other country in 2019 and 2020.

As environmental scientists, we study how society interacts with the environment, and how those interactions can change over time, often as a result of governmental policies. Recent political events in Colombia have been associated with major swings in societal and environmental indicators. Our analyses of these metrics suggest that formerly improving societal and environmental conditions rapidly deteriorated during the initial years of the current (2018–2022) administration. The 2022 elections provide Colombian voters with another choice that is likely to have long-lasting societal and environmental repercussions. In this case, and in democracies around the world, we believe that voters benefit from analyses and well-informed discussions of the environmental consequences of political decisions.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.envsci.2022.04.013](https://doi.org/10.1016/j.envsci.2022.04.013).

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